STATES, WATER, AND CLIMATE: WHO'S PLANNING FOR CHANGE?

by

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ABSTRACT

The primary objective of this study is to determine what drives water planners to plan for the impacts of a changing climate. As the climate continues to change, climate scientists have projected changes in water quantities available for human and other uses. This multimethod study addresses these questions through three interlinked studies focusing on state level data and planning.

The first study examines how Americans form policy preferences on climate change. This question is particularly relevant in today’s environment of decreasing public support, especially from 2008 onward, for climate change initiatives even as climate scientists’ confidence in future global warming increases. Results from previous research reporting several significant predictor variables for climate change policy preferences including scientific knowledge, partisan identification, general environmental beliefs, and vulnerability are tested with contemporary data at the state level. I found that following the 2008 election, partisan identification became a much stronger predictor at the state level while the other predictors diminished in importance.

The second study examines how state water plans and state hazard mitigation plans address climate change. Plans were coded for the extent to which they address climate change in their calculations for future supply and demand. Multivariable Linear Regression models were developed to test the predictive value of independent variables

including statewide voting, vulnerability to climate change, and recent experience with droughts and natural disasters. The most significant predictor variable for both state water planning and state hazard mitigation planning was the statewide voting record. Democratic leaning states were much more likely to plan for climate change in their plans than were Republican leaning states.

The third study is a qualitative comparison of the Texas and California state water plans. These two states were chosen because of their political differences but otherwise largely similar challenges with water resources, projected decreases in available water resources due to climate change, similar water planning paradigms at the state level, and similar demographics. While Texas is maintaining a traditional water planning effort focusing on infrastructure construction and conservation, California is focusing on environmental protection, social equity, and has adopted a scenario based approach accounting for uncertainties not only from climate change but also from population growth and changing demand patterns.

"Western water agencies must handle the collusion between 19th century water law, 20th century infrastructure and 21st century population and climate change."
Brad Udall
May 4, 2015

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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CHAPTER 1

STATES, WATER, AND CLIMATE: WHO'S PLANNING FOR CHANGE?

Political states have a long history of planning and building water resources infrastructure to meet the needs of their constituents dating back to the aqueducts built by ancient civilizations. Water resources planning by political states have been driven by several variables including politics but also water resource availability, population, and economic growth. In the US, the political states responsible for water planning are mostly state and local governments. This study will examine the extent to which different partisan compositions and policy preferences of elected leaders have led to different water planning paradigms particularly in the face of climate change.

Scientists studying the Earth's climate have increasingly concluded that the climate is changing as a result of human activities. For example, the United Nations chartered Intergovernmental Panel on Climate Change (IPCC) was established in 1988 "to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts" (IPCC, 2015, p. 1). As the body of evidence supporting anthropogenic climate change has grown within the scientific community, successive assessment reports have established with increasing confidence (to a point of near certainty) that anthropogenic, or human-caused, climate change has occurred since the industrial age and the rate of change will very likely accelerate in the future (e.g., Solomon, 2007). Scientists have also shown changes, and are predicting increasing changes, in the quantity and location of fresh water resources around the globe and in the US. These changes present both challenges and opportunities for political institutions such as states, water districts, and other public agencies charged with managing our water resources.

The work presented here will assess why political institutions with responsibilities for managing or supplying water resources are, or are not, responding to the challenges and opportunities posed by climate change in their planning and operational activities. To that end, the ultimate dependent variable for this work is the planning output of water management agencies, particularly at the state-level. Of particular focus are the state water plans produced by most western US states. The degree to which states are planning for a future that is different than the past, in that it captures the changing climate, will be examined and related to independent variables such as water resources' vulnerability to change, experience of drought, public opinion on climate change, and the predominant political leanings of states. This analysis will draw on theory and prior research on climate impact to develop and test hypotheses regarding what drives states to either plan for, or not plan for, the changing climate.

The results of this study will serve both practitioners and scholars. Those working with state risk management, natural resource management, city planning, environmental standards protection, and utility planning will be able to more effectively plan for water as a scarce resource. This study also speaks directly to scholars centered on climate change, sustainability, public policy, the intersection between science, policy making, and urban planning, as well as those interested in risk perceptions and risk management. Moreover, the findings emphasize the importance of political considerations in addressing climate change in water planning.

1.1 Justification

Understanding what motivates policy makers to apply climate science in water management policies is important for two major reasons: (1) it will improve our ability to explain and predict water resource agencies behaviors and, more pragmatically, (2) it might strengthen our society's capacity to apply climate science in water management, and, thereby, improve our societal capacity for scarce resources' climate adaptation.

Water management agencies exist at different levels of government and in the private sector. These agencies are responsible for providing water to water users ranging from residential consumers to large scale agricultural consumers. Examples of water management agencies include local public utility districts, state-level departments of water resources, and the Bureau of Reclamation at the federal level. There are also private sector companies engaged in water resources management. These agencies are generally understood by scholars to be risk adverse entities that tend to hold service reliability, i.e., access to safe and affordable water, above all other considerations and goals (Rayner, Lach, & Ingram, 2005). Customers expect high quality water to be available when they need it. The public's tolerance for failure is very low, especially with regard to municipal water providers in the US, whose customers expect clean water when they turn on their taps. The barriers to implementing changes to successful procedures, or changes that are costly in an ongoing successful water management regime, are quite high. Nonetheless, climate change has and will increase vulnerabilities in the water management area, and it will increase the risks that agencies managing this scarce resource will face. This is particularly the case in the semiarid western US, where the balance between water supply and demand is already stressed. Improving our understanding of what motivates, hinders, and supports changes in the planning and/or the operations of water management agencies will add to the field of political science. In particular, analyzing the relationship between politics including elected leaders, constituent preferences, and water planning will add to the understanding of how these risk-averse water management agencies operate and plan.

From a more normative and pragmatic perspective, improving the ability of water management agencies to plan for and operate in a changing climate, is an important aspect of improving our *societal* ability to deal with changing climate. If we fail to plan and account for changes in our water supply stemming from a changing climate, such as a decreased availability of water, we jeopardize our way of life.

1.2 Analysis of Prior Research

The body of research on the application of climate science in water management is dominated by anecdotal evidence and qualitative studies that focus primarily on inputs to water management agencies regulations, rules, forecasts, and science. These studies focus less on the output that water management agencies produce based on scientific information and regulation inflow. For example, Pulwarty and Redmond (1997) used a semi structured interview strategy as they spoke with water managers in the western US to assess the extent to which water managers utilize climate forecasts in their work. They found, similar to others, that water managers generally do not use climate forecasts in their work (e.g., Callahan & Miles, 1999; Rayner et al., 2005). Instead, most water management strategies are tied to standard operating procedures that prescribe actions based on observed conditions, such as reservoir levels, the time of year, and the amount of snow on the ground.

Quantitative and large *N* research approaches in factors driving use of climate science in state water planning are rare. One atypical example of such an approach looking at the use of forecasts in water resources management, however, is a survey from the year 2000 (Dow, O'Connor, Yarnal, Carbone, & Jocoy, 2007; R. E. O'Connor, Yarnal, Dow, Jocoy, & Carbone, 2005). Water managers in South Carolina and the Susquehanna River Basin of Pennsylvania were given a written survey. The survey was designed to assess (1) the size of respondents' water management responsibilities, (2) the perception of their own risk for system failure (e.g., not being able to supply their customers with water), and (3) the managers' perception of climate and weather forecast skill. The survey response was substantial for both regions (N = 405 in Pennsylvania and N = 269 in South Carolina), allowing for a robust statistical analysis of the results (O'Connor et al., 2005). The results showed that only a small percentage of water managers used climate and/or weather forecasts for flood protection, water supply, and power generation in either state. Only 10-25% of the managers surveyed reported using forecasts to plan for future water storage needs, expanding distribution systems, adjusting reservoir levels, adjusting inventory supply needs, or similar uses. Two purposes showed higher forecast usage: 1) scheduling personnel for maintenance and construction, and 2) starting public information campaigns to conserve water. The O'Connor et al. (2005)

analysis showed that the perceived risk of system failure was significantly correlated with managers' willingness to use climate forecasts in their decision-making. In other words, if a particular agency were at some risk of not meeting its water delivery or water quality requirements, it would be willing to seek new information (such as a climate forecast) to help make its decisions. The analysis also showed that agency size and the perception of forecast skill did not correlate strongly with actual use of, or willingness to use, climate forecasts. Therefore, O'Connor et al. (2005) conclude that application of climate science and forecasts in water management is more determined by perception of risk, particularly with recent experiences with extreme weather and climate, than by any improvements in forecasting skills or the potential value of climate science for the intended end user. These results are consistent with other studies that were more anecdotal and qualitative in nature with small samples and interview based methods (e.g., Pulwarty & Redmond, 1997) in other parts of the country and world.

Water supply systems' vulnerability to failure is obviously related to variation and trends in water supply from, for example, groundwater or surface water supply from watersheds. Many studies have examined vulnerabilities to water shortages. For example, a recent study by Averyt et al. (2013) examined stress on fresh water resources in the US. They developed a water supply stress index based on observed water use and supply at approximately 700 square miles (the standard 8 digit Hydrologic Unit Code scale used in the US). They applied their water supply stress index to both current supplies and water usage. Their results showed that the stress is greatest in the southwestern US. This is the same geographic region that expects to see the greatest declines in fresh water supply as a result of climate change.

As noted above, much of previous research has focused on input to and planning by water management agencies. The studies described thus far largely assess whether climate science and forecasts are used as input at all to decision making. Much less attention has been paid to whether decisions that are made or output from water management agencies considering climate adaptation are significantly different than they would have been if they had not considered climate change.

One recent example of a study focused on agency output related to climate change, but not specifically in water resources, is Babcock (2013). Babcock examined the state Hazard Mitigation Plans that each state is required to produce in order to be eligible for the Federal Emergency Management Agency (FEMA) funding following a disaster. Each plan was assessed for its treatment of climate change using objective analysis techniques, such as word frequency analysis, and subjective techniques, such as assessing accuracy of climate change content. Among other things, Babcock found that coastal states have addressed climate change in their plans to a greater extent than landlocked states.

Looking more broadly, previous research has found coherent relationships between a) policy preferences of constituents and b) the policy choices of their elected government. Page and Shapiro (1983) and Monroe (1998) both examined this relationship using survey data to represent policy preferences of Americans and an analysis of laws passed by Congress to represent policy choices of the US government. As expected, Page and Shapiro found a general congruence between changes in public opinion and policy choices by the government. Monroe (1998) found a somewhat less consistent relationship between public opinion and policy choices of the government representing that public. Page and Shapiro (1983) and Monroe (1998) suggest that constituent political preferences around climate change may impact how climate change science is used by water planners who are charged with supplying water to those constituents.

While the body of research on the application of climate science in water management and planning has provided a solid foundation that identifies predictor variables related to vulnerability and public opinion, it has also left significant opportunities for further research. In particular, an assessment of planning by water management agencies at the state-level and the extent to which they address (or do not address) climate change is still lacking. There is also an opportunity to explore the relationship of policy and planning output to the predictor variables.

1.3 Research Question

Previous research suggests water resource agencies will address climate change with their actions based on (1) vulnerabilities and (2) constituent support. The questions this study poses are the following: Is there evidence that water resources vulnerability to climate change motivates application of climate science in water planning? Is there evidence that political preferences about climate change policy from elected leaders or constituents motivate application of climate science in water planning? More basically, is there evidence that partisan political preferences motivate policy choices around climate change? These questions unify the studies presented in the succeeding chapters.

1.4 Research Design

Three avenues of research are conducted to shed light on what could hamper or support a) the use of climate information and b) the willingness to address climate change through decisions and policies. The first study assesses the motivators including ideology, partisanship, and perception of risk for state populations' willingness to take policy action to adapt to climate change (Chapter 2). The second study examines state water plans and state hazard mitigation plans, which are an output of state government, and the extent to which these plans address climate change (Chapter 3). The third and final study is a case study examining in more detail the water plans of two states with fundamental differences in their planning for the changing climate, California and Texas (Chapter 4). Chapter 5 then discusses conclusions across all three studies and their implications for practitioners and researchers.

CHAPTER 2

WHO WANTS TO DO SOMETHING ABOUT CLIMATE CHANGE?

While atmospheric scientists have studied the Earth's climate for over a century, the body of scientific evidence for anthropogenic changes in the observed and projected climate record is relatively recent. For example, the United Nations chartered Intergovernmental Panel on Climate Change (IPCC) was established in 1988 and has produced a series of four assessment reports (with a fifth currently in progress). As the body of evidence supporting anthropogenic climate change has grown within the scientific community, successive assessments have reported with increasing confidence, to a point of near certainty, that anthropogenic climate change has occurred since industrialization and the rate of change will very likely accelerate in the future (Solomon, 2007). For most of the past two decades, American public opinion roughly followed the building scientific confidence in attributing climate change to anthropogenic activities. However, since 2008, American public opinion has moved in the opposite direction – increasingly questioning climate science that is showing anthropogenic influences and souring toward policy initiatives to mitigate climate change (Pew, 2009, 2010). This decline in public support was particularly pronounced in 2008 and 2009 with public opinion reductions of 10-20% in both Pew Center and Gallup survey data. These observations contrast with studies in political science that have shown the importance of experts in driving public opinion. For example, Page et al. (1987) showed that “experts” were able to influence public opinion on policy matters. This finding appears to be at odds with the trends in opinions on climate change within and outside the scientific community that we see from 2008 onward. The literature on climate change policy preferences is surprisingly well developed and has identified several independent variables that work together to explain much of the variance in American policy preferences on climate change prior to 2008. This literature will be reviewed in the next section. However, the rapid recent changes in public opinion call into question the continued validity of those previous results. The purpose of this chapter is to investigate these relationships at the state-level to assess if the independent variables other scholars have found to be significant at the individual-level are significant when aggregated to the state-level. This is important for determining policy preferences at the state-level for water planning (the subject of Chapter 3). Following a literature review of relevant theories posited by other scholars, I will present the data and regression based methodology for testing the relationships between predictor variables for climate change preferences at the state-level. Then I will present my results and offer a conclusion that the shaping of policy preferences related to climate change has changed.

2.1 Theory

Previous research on climate change policy preferences in the scholarly literature has reported several important predictor variables. While much of this research has been conducted in the past 15 years, the roots of this research extend back to 1960s research on factors shaping the broader environmental interests of Americans. Since the science community first identified climate change as a policy relevant issue and began refining its results in the 1980s, social scientists have been studying people's policy preferences related to climate change.

O'Connor et al. (1999) studied American policy preferences and individual choices related to climate change. In particular, they used a 1997 mail survey distributed randomly to adult Americans to assess the importance of four predictor variables on two separate dependent variables – willingness to take certain voluntary actions to mitigate climate change (e.g., carpooling, buying fuel efficient cars) and support for policy initiatives to mitigate climate change (e.g., gas tax or cap and trade). The four categories of independent variables considered were demographics, attitude toward government, climate change risk perception, and general environmental beliefs. They found that all four categories of independent variables had explanatory power for each dependent variable. Importantly, they found that risk perception of system failure explained roughly equal amounts of variance in both dependent variables. Previous literature had established the importance of the other independent variables but risk perception was new. The results of O'Connor et al. (1999) built significantly on a framework by Dunlap and Van Liere's (1978), which measured general environmental beliefs by showing the importance of also measuring risk perception for explaining attitudes toward climate change. In addition to the main finding, O'Connor et al. reported that "climate change is not a polarizing issue, but one about which most people are unclear on what government policies they should support" (1999, p. 467). This result that people are generally unclear on policy remedies to address climate change was supported by survey responses showing the majority of respondents as indicating only mild support for six of the seven policy positions proposed in the study. Finally, the study reported that “knowledge about the causes of global warming is a powerful predictor of behavioral intentions, independent from believing that climate change will happen and have bad consequences” (O'Connor et al., 1999, p. 469).

O’Connor et al. (2002) further explored the link between scientific knowledge and policy preferences in a survey based study examining the attitudes and behaviors of central Pennsylvanian residents. Central Pennsylvania is a major producer of coal. As such, the population faces economic risk from many proposed policies to address climate change. Interestingly, O’Connor et al. found that partisan identification was a statistically significant predictor of policy support, but not of individual voluntary action to address climate change. This is interesting in that individual voluntary actions were not driven by partisan identification. They also found that knowledge of the causes of climate change in particular, and education in general, werer significant predictors of support for climate change policy.

Knowledge of climate science has been studied both as a stand-alone topic and as an independent variable predicting climate change policy preferences (e.g., O'Connor et al., 1999). Sterman and Sweeney (2007) examined basic knowledge of climate science and simple mass balance concepts, which are important for devising policies to address climate change, such as the relationship between greenhouse gas emissions and greenhouse gas concentrations in the atmosphere. They used a short answer and multiple choice survey instrument. Their respondents consisted of 212 graduate students at the Massachusetts Institute of Technology. They found a surprising lack of understanding of basic concepts such as stock and flow, and mass conservation among a majority of the respondents. For example, they found “a large majority, 63%, assert[ed] atmospheric CO2 can be stabilized while emissions into the atmosphere exceed removal from it” (Sterman & Sweeney, 2007, p. 13). Sterman and Sweeney (2007) conclude that policy making and policy preferences are very problematic when a majority of the population and policy makers lack a rudimentary understanding of the concepts involved in the policy issue.

Another possible variable driving policy preferences toward climate change is perceived or actual vulnerability to climate change. The impacts of climate change are not uniform in space and time. For example, rising sea levels will affect coastal areas but not inland areas. Decreases in fresh water supply are expected to occur mostly over the semiarid southwestern US, where water is already scarce, but not over much of the rest of the country. Trends and variability in time such as decreasing snow pack or major droughts may also affect risk perception. Thus, risk perception may be expected to depend, in part, on physical location and time. However, scholars have so far only found weak relationships between physical vulnerability to climate change and risk perceptions.

Brody et al. (2008) used survey data in combination with weather and geospatial data to study variables explaining climate change risk perception (their dependent variable). Physical vulnerability variables included distance to coast, recent fires, property damage, local temperature trends, and location in floodplains. Social variables included Dunlap and Van Liere’s (1978) New Ecological Paradigm (NEP) scale and similar demographic data to O’Connor et al. (1999). They found that the physical vulnerability variables explained only about 4% of the variance in climate change risk perception whereas the social variables explained about 40%. The later number is consistent with other studies presented here. Hamilton and Keim (2009) also examined the spatial variability of climate change risk. They utilized survey data from the Community and Environment in Rural America survey conducted by the Carsey Institute in 2007 to compare perceptions of climate change in nine rural American areas. Similar to Brody et al. (2008), they found small differences in perception between communities that are more vulnerable to climate change impacts compared to those that are less vulnerable. In particular, they found that respondents in mountain communities that have seen decreases in snowpack perceive major climate change impacts at about 10 percentage points higher than other rural communities. Arcury and Christianson (1990) studied the impact of a major drought in Kentucky on environmental beliefs using the New Environmental Paradigm scale developed by Dunlap and Van Liere (1978). They surveyed Kentucky residents before (1984) and after (1988) a drought to assess changes in environmental beliefs that might be attributed to the drought they experienced. They found only very small changes between the two surveys. These studies indicate that in the US, at least to date, there is not a strong relationship between physical vulnerability and risk perception.

The explanatory power of ideology and partisan identification on climate change beliefs has been studied and well established by scholars. McCright and Dunlap (2011), for example, examined Gallup polling data for 2001-2010. Over that 10 year period, they found that 69% of liberals but only 43% of conservatives believed global warming has already started to happen. They reported similar statistics for other measures of knowledge, perception, and policy preferences related to climate change. These findings are consistent with what other polling data have shown (e.g., Pew, 2009, 2010). Findings on the relationship between partisan identification and climate change perception variables are similar to those reported for ideology and climate beliefs. In addition, McCright and Dunlap (2011) explored the conditional effects of education and climate science knowledge on both partisan identification and ideology. They found that both education and climate science knowledge exacerbated differences between liberals and conservatives, and between Democrats and Republicans. For example, when only respondents with college degrees are considered, 82% of liberals and 43% of conservatives report that they believe climate change is already occurring. Similarly, among those that self-report greater understanding of climate change, 83% of liberals and 36% of conservatives report that they believe climate change is already occurring. These results suggest a polarization among well-educated Americans, roughly along party lines. McCright and Dunlap (2011) reported that this polarization has intensified over the decade that Gallup polled on these questions. Among Democrats, there is a small trend toward a greater belief that climate change is occurring, whereas far fewer Republicans believe this, particularly since 2008 (down from ~45% to ~30%). McCright and Dunlap (2011) speculate that this increasing polarization results largely from the influence of the media.

McCright and Dunlap's (2011) conclusions regarding polarization are at odds with the earlier findings of O'Connor et al. (1999) that Americans are not polarized on the issue of climate change. While some of this is likely the result of events that transpired in the years between the two studies, McCright and Dunlap's (2011) dataset is quite simplistic compared to the O'Connor et al. study (1999). O'Connor et al. (1999)

utilized a Likert scale to assess willingness to change personal behavior and support different policy positions, whereas McCright and Dunlap (2011) had a single, binary dependent variable that measured a belief that global warming has already started happening. This limitation is significant and prevented a more thorough analysis of the extent of polarization around specific or general policy questions.

Recently, Marquart-Pyatt et al. (2011) issued a call for additional research to better understand American policy preferences on climate change. They identified four areas for future research to better understand the drivers of American public opinion on climate change policy. First, they called for in-depth longitudinal survey data collection over a number of years designed to rigorously assess policy preferences, scientific knowledge, trust, and household mitigation actions. Second, they called for more research on the role of trust in shaping policy preferences. Marquart-Pyatt et al. (2011) advanced the concept of where people place their trust as a possible independent variable for climate policy preference. Third, they called for research into the effects of media and social networking on public opinion. Finally, they called for a better understanding of the relationship between opinion and personal behavior. This last point is particularly important if public policy continues to fail to address climate change, as changing personal behavior may be an alternative to addressing climate change through larger scale policy initiatives.

Table 2.1 summarizes the literature reviewed here in chronological order. Figure 2.1 summarizes the literature and the relationships between the studies considered here and their relationship to understanding American policy preferences on climate issues: the ultimate purpose of this chapter. The literature considered here has identified a number of important independent variables and demonstrated their relationship to the dependent variable as shown in Figure 2.1.

In order to assess the impact of policy preferences and politics on state water planning efforts, the unit of analysis in this study is state-level data. This study examines the extent to which independent variables found to be significant predictors of individual-level policy preferences around climate change are significant at the state-level when data is aggregated to that level. Similar to many of the studies reviewed, the dependent variable for this study is policy preferences on climate change but at the state-level rather than the individual-level. Somewhat consistent with the literature reviewed, the independent variables are the following: presidential vote choice, general environmental beliefs, climate science knowledge, and physical vulnerability. Note that risk perception is excluded from this analysis for a lack of available data.

Based on the theory presented earlier in the chapter, I hypothesize the following:

- H1: State-level relationships – The relationships reported by previous researchers should be present at US state-level and, therefore, observable using statewide data.

- H2: Climate policy preferences – Consistent with previous research, climate change policy preferences should exhibit significant relationships to partisanship, scientific knowledge, and general attitude toward the environment. Vulnerability to environmental risk should not exhibit a significant relationship.

- H3: Changes over time – I hypothesize that the H2 relationships should be the same before and after 2008.

2.2 Method

Data for this study come from several sources. The response variable, American policy preferences for climate change, is drawn from a recurring Pew Center survey conducted in 2007 and 2010 (Pew, 2007, 2010). The 2007 survey was conducted January 10-15, 2007 and had 1708 respondents. The 2010 survey was conducted from October 13-18, 2010 and had 2251 respondents. Respondents in both surveys were randomly selected and designed to approximate the national population.

Each survey asked respondents, "Do you think global warming is a problem that requires immediate government action, or don’t you think it requires immediate government action?" (Pew, 2010). In 2007, 55% of respondents responded that immediate government action was required while 31% said government action was not required, and 11% responded that global warming was not a problem. Just 4 years later, the responses were markedly different with 44% of respondents responded affirmatively, 29% negatively, and 24% responded that global warming was not a problem.

Data from both surveys were aggregated (separately for each year) to the state-level in order to study relationships at the state-level. These variables’ unit of analysis is aggregated state responses rather than individual responses. The aggregation permits the incorporation of other datasets at the state-level that are not present in the survey into this analysis. This also permits the use of data analysis techniques for interval level variables. Liu (2007) and others have discussed the potential problems, but have also demonstrated opportunities associated, with using aggregate data. In this case, the use of aggregate data permits the integrated analysis of data from different sources. Unfortunately, some states with small populations do not have a sufficient number of responses in the Pew Center survey results to adequately represent a state. States with fewer than 25 respondents in the 2010 survey were excluded from the analysis (leaving 27 states). The results are not sensitive to the threshold (e.g., 25 respondents) selection. Of the included states, Oregon reported the highest number of positive respondents (63%) and Alabama the fewest (20%) in 2010. Figures 2.2 and 2.3 show affirmative survey results by state for 2010 (Figure 2.2) and 2007 (Figure 2.3).

Data for independent variables come from several sources. A different Pew Center survey provides data on scientific knowledge related to climate change (Pew, 2009). Two thousand and one American adults were surveyed regarding their attitudes and perceptions of science. The survey was conducted from April 28, 2009 to May 12, 2009 and was designed to be representative of the nation's voters. The margin of sampling error was +/- 2.5%. This survey asked respondents, "What gas do most scientists believe causes temperatures in the atmosphere to rise?" (Pew, 2009). The correct answer is carbon dioxide. The state aggregated results will be used as a measure of climate change science knowledge in our study.

The 2008 and 2012 election results and 2009 average education attainment are used as independent variables in this analysis (Census, 2011; FEC, 2012). In particular, the statewide vote for the 2008 Republican candidate, John McCain, and the 2012 Republican candidate, Mitt Romney, are used to represent political preferences at the state-level. The percentage of state residents with a bachelor degree or higher in 2009 represents the educational attainment statewide. Vulnerability to natural disasters is operationalized by the number of declared disasters by state from 1953 to 2011 (FEMA, 2011). Finally, I use a state-by-state rating of environmental policies from *Forbes* magazine considering state policies, public opinion, and the state of the environment to represent general attitude toward the environment (Wingfield & Marcus, 2007).

2.3 Models

This study employs multivariate linear regression (MLR) modeling to assess the relationship between the independent and dependent variables in 2007 and 2010. Separate models are developed for the 2010 and 2007 survey results in order to compare the results. The two equations are:

$$Y07 = A + B1X1 + B2X2 + B3X3 \tag{2.1}$$

$$Y10 = A + B1X1 + B2X2 + B3X3 \tag{2.2}$$

where the dependent variables, *Y07* and *Y10*, are the percent support for government action to address climate change in the 2007 and 2010 survey results, respectively. The predictor variables are X1, the vote percentage for John McCain in the 2008 presidential election, X2, the 2007 state environmental ranking, and X3, the 2009 percent correct for climate science knowledge. A similar model is constructed replacing the 2008 presidential election results with the 2012 presidential election results to test changes over those four years. Other independent variables described in the previous section were tested in different linear models but did not contribute significant predictors and are, therefore, not reported in the model results here.

2.4 Results

Table 2.2 reports the model results for the 2007 independent variable. Two of the three independent variables were significant at the 95% significance level using a once sided *t* significance test: climate science knowledge and the state green rating. The use of the one-sided test is appropriate given the theory expecting a positive correlation between these two predictor variables and climate change policy preference. The linear model explains 41% of the variance for the state-level data used in this study. These results are consistent with previous investigations by other scholars using individual-level data.

Table 2.3 reports the model results for the 2010 independent variable. This model shows that, unlike in 2007, the only significant predictor is the presidential vote of 2008. This result was robust across models with different predictor variables and different thresholds for state respondent sample sizes. While previous studies have reported that partisan identification and ideology are significant predictors of climate policy preferences (e.g., McCright & Dunlap, 2011), none have shown that general environmental attitudes and scientific knowledge are insignificant.

More MLR models were constructed to test relationships with other independent variables. Consistent with previous investigations, perceived physical vulnerability was not found to be a significant predictor for either year or in any combination with other independent variables (result not shown). Demographic data, such as education attainment, gender, and geography (e.g., urban vs. rural) that were found to be significant predictors in previous research were largely found to be insignificant in this analysis (results not shown). This result may be caused by the use of state-level analysis which tends to “wash out” significant differences at the individual-level when the average of these independent variables is roughly similar across all states.

Figure 2.4 and 2.5 show the effect displays for the two linear models reported above. Effect displays are tools for showing relationships between each predictor variable on the response variable across the range of values of the predictor variables (Fox & Weisberg, 2010). In each figure, an effect display plot is generated for each of the three predictor variables. The actual values for the predictor variables are shown as the hash marks along the abscissa. The best fit regression line is indicated in black whereas the red dashed envelope indicates the confidence in the MLR. A smaller area in the envelope indicates stronger confidence.

In Figure 2.4, for the 2007 model, all three variables show a nonzero best fit regression line however; as expected from the tabular results, the confidence in the X1 predictor variable (e.g., the 2008 presidential vote) is not sufficient to reject the null hypothesis that there is no effect from this variable. In contrast, both X2 and X3 show strong positive relationships with the *Y07* response variable (e.g., 2007 climate policy preferences).

Figure 2.5 paints a much different picture for the 2010 model. Here, X1 is strongly negatively related to the *Y10* response variable (e.g., 2010 climate policy preferences) while the best fit line for X2 and X3 are both very nearly zero. The confidence envelope around X2 and X3, in this case, is quite large indicating that the probability that the true relationship between Y2 and X2 and X3 is zero, is substantial. These plots depict the dramatic difference between the 2007 and 2010 MLR model results with X2 and X3 clearly being much more significant in 2007 than in 2010 while X1 is more significant in the 2010 model.

Figure 2.6 shows the effect display for the 2010 model with the election result independent variable updated to the 2012 presidential election. Like the first 2010 model reported in Figure 2.5, this one shows election results as being the only statistically significant predictor variable. Further, the 2012 presidential election is an even stronger predictor than the 2008 presidential election.

Returning to the hypothesis statements, H1 regarding the robustness of state-level relationships is largely confirmed by these results, with the exception of the demographic independent variables. Hypothesis H2 regarding the consistency of response and predictor variables with previous research results is largely confirmed for 2007, but rejected for 2010. Hypothesis H3, stating that relationships should be stable over time, is rejected in the face of these results.

2.5 Conclusions

Taken together, these results suggest that a fundamental shift in the way Americans are constructing their policy preferences related to climate change may be taking place, whereby partisan choice and/or ideology may be becoming a much more important predictor than in the past and other predictor variables important in the past are becoming less so. While the relationship in 2007 between the response and predictor variables reported here is similar to previous results reported in the literature, the relationship is fundamentally different in the results for 2010. In particular, the presidential vote is a much more significant predictor for 2010 than in 2007, while the other independent variables considered in the models presented here (as well as other variables in models not reported here) are far less significant in the 2010 results.

These results are, of course, only as good as the data included in the models. Certainly, the state-level data have larger uncertainty in the estimation of variable values than individual-level survey response data. The ability to tightly operationalize variables consistent with the theory is also more limited with state-level data than with individual survey questions especially for surveys that the researcher constructs specifically for the purpose of their inquiry. For example, the state green index rating used in this study is not as robustly developed for measuring general environmental attitudes as the widely cited and applied New Environmental Paradigm (NEP) scale (Dunlap & Van Liere, 1978). However, the similarity of the 2007 results to previous research results suggests that the state-level methodology used here is accurate if not precise. Further, the 2010 survey responses are consistent with the downturn in public opinion on climate change policy reported by Pew and others from 2008 onwards.

More time and data are needed to assess the strength of this conclusion. In particular, additional surveys repeating the Pew question representing the dependent variable (e.g., respondent’s willingness to endorse government action to address climate change) would go a long ways toward validating the findings of this study and toward tracking changes in these drivers of public opinion across time. In the meantime, it is worth considering the political and economic changes in America in and since 2008, as well as media effects. The major economic recession and its impact on American politics and policy priorities certainly merit further investigation. Economic strain during recessions can clearly modify political preferences to be more focused on basic issues such as social services and jobs and away from issues like the environment. State-level analysis using economic data could follow this methodology. If economics are responsible for driving the changes observed here, incorporating state-level economic data – especially changes in state economic conditions since 2007 - would be a useful avenue of future research.

Political changes with the 2008 election of President Obama, backlash against his progressive platform, and perceived expansion of government may also have contributed to the changes in climate policy preferences reported here. In particular, the combination of a progressive president heralding from urban America with the election of a strongly Democratic and progressive Congress in 2008 shifted political power and discussion to policy areas and policy choices that had not been previously under discussion. The backlash in the conservative political ranks was strong, as evidenced by the rapid growth of the Tea Party and the major shift in the 2010 and 2014 Congressional elections. This political tension may have contributed to the results reported here. More data on state-level political shifts would be useful for diagnosing this possibility.

The effects of the media, in particular, the rapid growth of the politically conservative media, on climate change policy preferences have been the subject of much speculation in the literature (e.g., Marquart-Pyatt et al., 2011; McCright & Dunlap, 2011; Oreskes & Conway, 2010). Much of the media has reported on the climate change issue using the same horse race approach as it does with many other issues, giving equal time and attention to both sides even when there is near total consensus among experts, as is the case with climate change science. Furthermore, many have speculated on the impact of the growth of conservative media and its treatment of science issues such as climate change but also including stem cell research, evolution, and other science issues. In many instances, the conservative media has challenged consensus science on all of these issues with pseudoscientific results being misrepresented as actual scientific output. This may amplify existing behaviors where voters utilize partisan identification as a schema for shaping opinion on complex issues such as climate change (e.g., Lodge & Hamill, 1986). This is clearly an area that needs further investigation.

Finally, as Marquart-Pyatt et al. (2011) advocate, better understanding the policy preferences and choices of Americans is clearly an area ripe and important for future research. Understanding how those preferences and choices are formed, but also how they change over time, is important to broader questions of science and policy interactions but also for how public policy may ultimately address the changing climate. Observations such as the statement of O'Connor et al. (1999) that "climate change is not a polarizing issue, but one about which most people are unclear on what government policies they should support" need to be revisited.

Table 2.1: Chapter 2 literature summary

(Dunlap & Van Liere, 1978) (Dunlap, Van Liere, Mertig, & Jones, 2000)	Developed New Ecological Paradigm scales to gauge public opinion toward environmental issues; documented change in perception in Washington State
(Arcury & Christianson, 1990)	Documented weak trends in environmental beliefs resulting from a major drought in Kentucky in the mid 1980s
(O'Connor et al., 1999)	Showed importance of climate change risk perception in explaining policy preferences and individual choices. Risk perception was shown to be about as important as and independent from general environmental beliefs.
(O'Connor et al., 2002)	Studied climate change policy preferences and willingness to take individual voluntary action in central Pennsylvania.
(Sterman & Sweeney, 2007)	Found a surprising lack of basic science knowledge among MIT graduate students in climate science and underlying concepts important for policy formation
(Brody et al., 2008)	Found weak relationship between physical vulnerability to climate change and risk perception
(Hamilton & Keim, 2009)	Found small differences in rural American communities on climate change perception that weakly correspond to climate trends
(McCright & Dunlap, 2011)	Used Gallup polling data to show polarization along partisan identification and ideology with respect to climate change.
(Marquart-Pyatt et al., 2011)	Call for additional research to improve understanding of the variables that shape public opinion on climate change policy.

Table 2.2: MLR Model results for 2007 climate policy preference. B estimates are the MLR coefficients, SE is the standard error, and P is the p values.

Variable	B Estimate	SE	P
McCain 2008	-0.0012	0.0026	0.6407
Green Index 2007	0.00433	0.0027	0.1186
Climate knowledge	0.6324	0.3042	0.0485*
Intercept	0.0121	0.2475	0.9615
$R2$ = 0.4165, F-statistic = 5.711, *=significant at 95%, n = 27			

Table 2.3: MLR Model results for 2010 climate policy preference. B estimates are the MLR coefficients, SE is the standard error, and P is the p values.

Variable	B Estimate	SE	P
McCain 2008	-0.0066	0.0028	0.0264*
Green Index 2007	0.0002	0.0029	0.9351
Climate knowledge	0.1093	0.3284	0.7422
Intercept	0.6636	0.2671	0.0204*
$R2$ = 0.3392, F-statistic = 4.107, * = significant at 95%, n = 27			

Table 2.4: Modified 2007 MLR Model results replacing 2008 election results with 2012 election results.

Variable	B Estimate	SE	P
Romney 2012	-0.1776	0.2759	0.526
Green Index 2007	0.0038	0.0029	0.199
Climate knowledge	0.6359	0.3021	0.046*
Intercept	0.0535	0.2626	0.840
$R2$ = 0.4211, F-statistic = 5.819, *=significant at 95%, n = 27			

Table 2.5: Modified 2010 MLR model results replacing 2008 election results with 2012 election results

Variable	B Estimate	SE	P
Romney 2012	-0.7369	0.2961	0.0202*
Green Index 2007	-0.0007	0.0031	0.8043
Climate knowledge	0.0974	0.3242	0.7665
Intercept	0.7473	0.2817	0.0139*
$R2$ = 0.3522, F-statistic = 4.349, * = significant at 95%, n = 27			

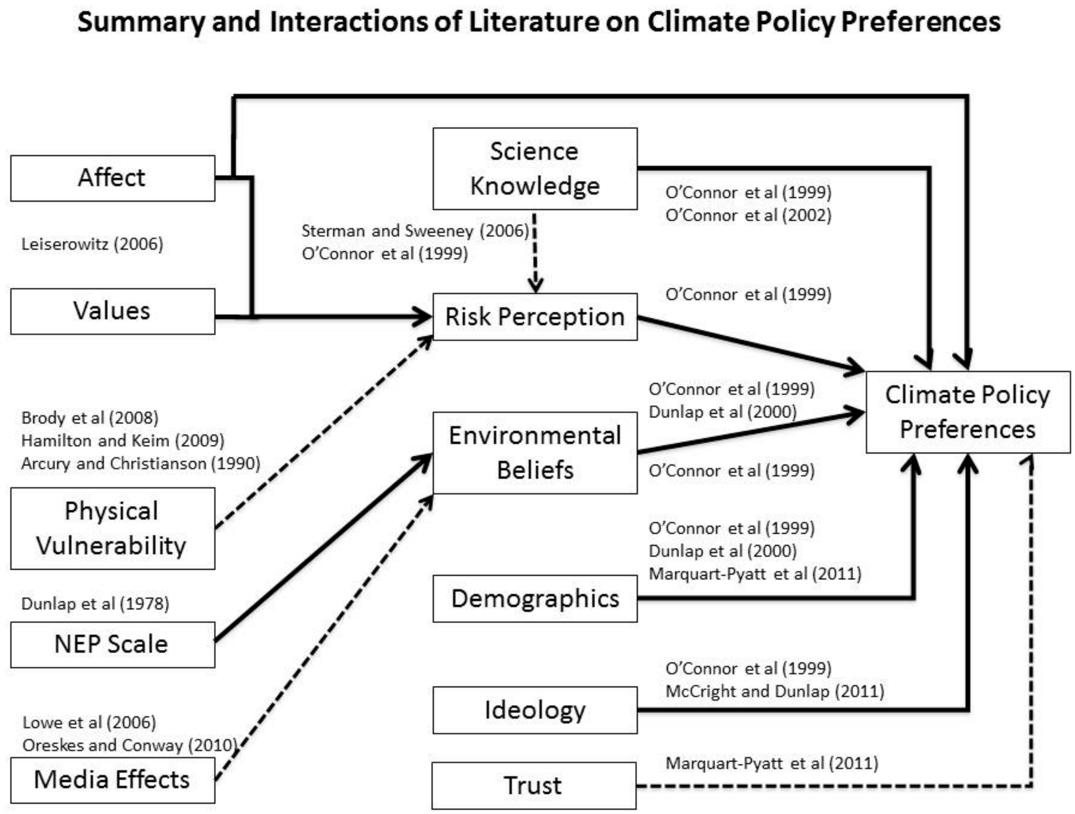

Figure 2.1: Interactions of research on American climate policy preferences. Solid lines indicate relatively strong relationships in the associated literature. Dashed lines indicate weaker relationships.

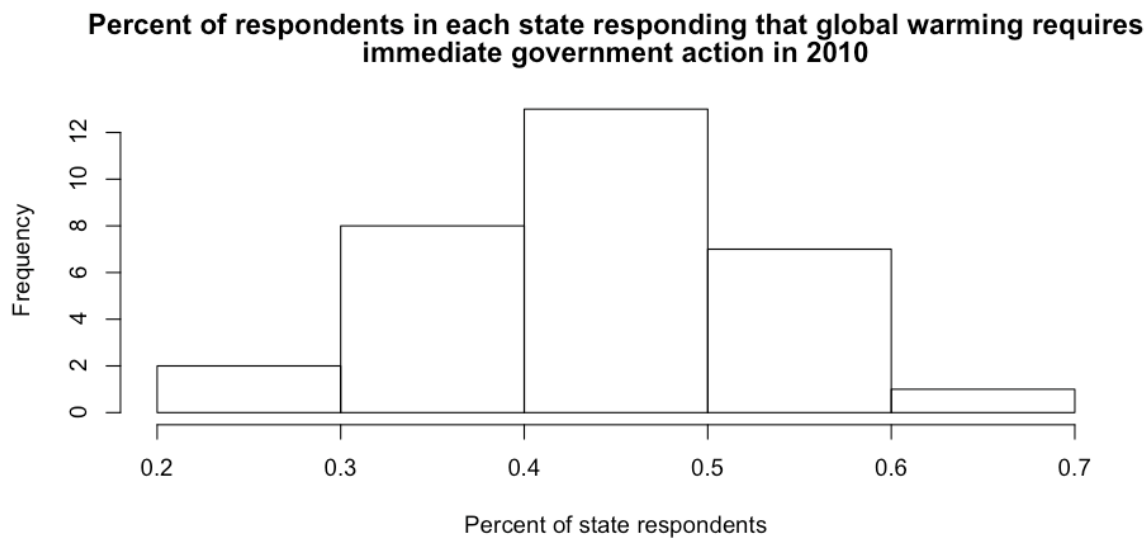

Figure 2.2: Percent of Pew (2010) respondents in each state stating that global warming requires immediate government action.

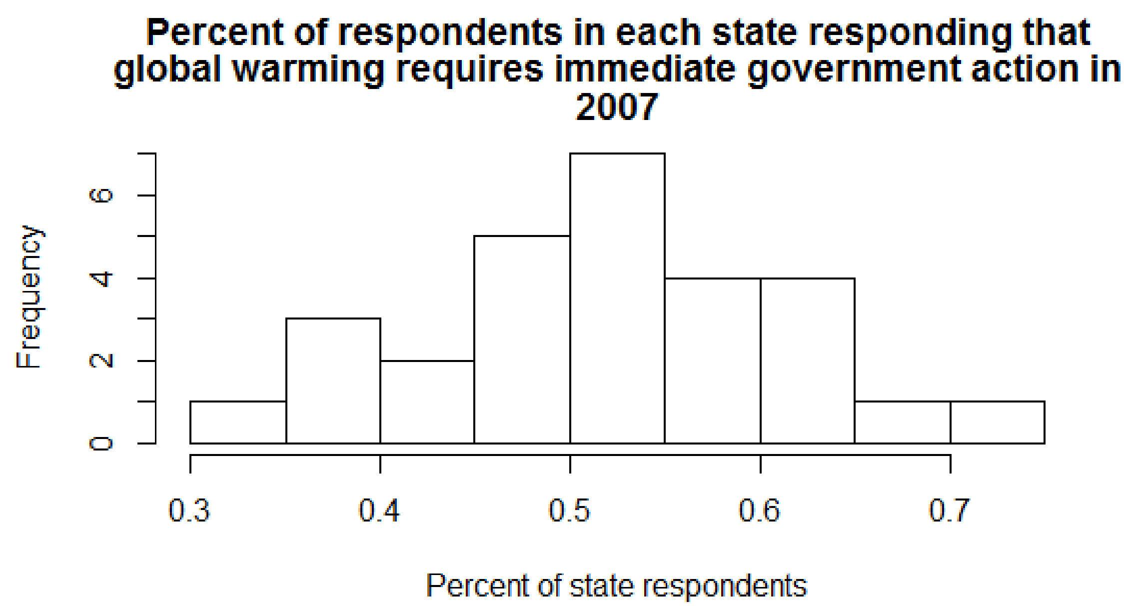

Figure 2.3: Percent of Pew (2007) respondents in each state stating that global warming requires immediate government action.

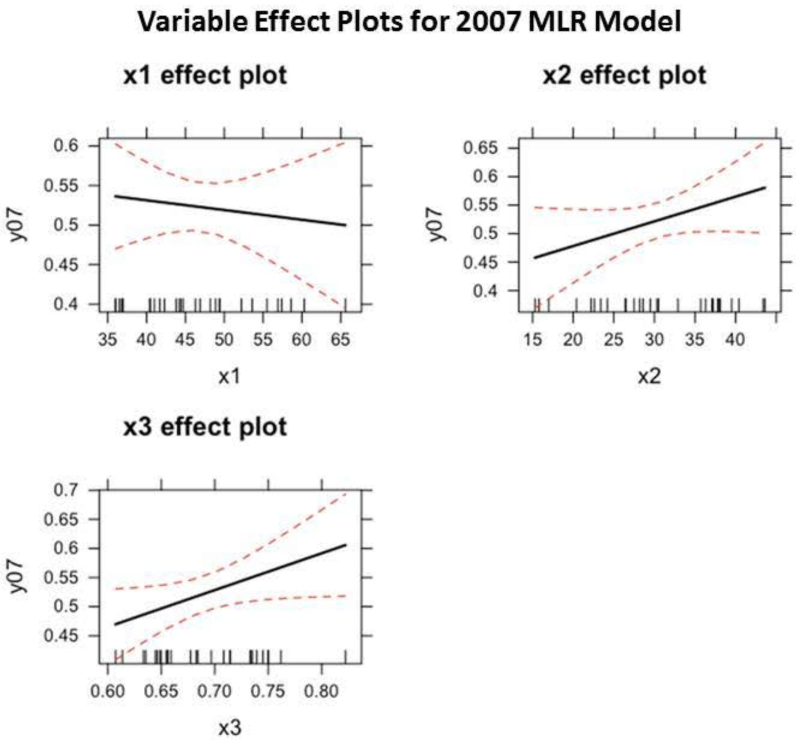

Figure 2.4: Effect display for 2007 MLR model described in text following Fox and Weisberg (2010). Variable names follow convention described in text.

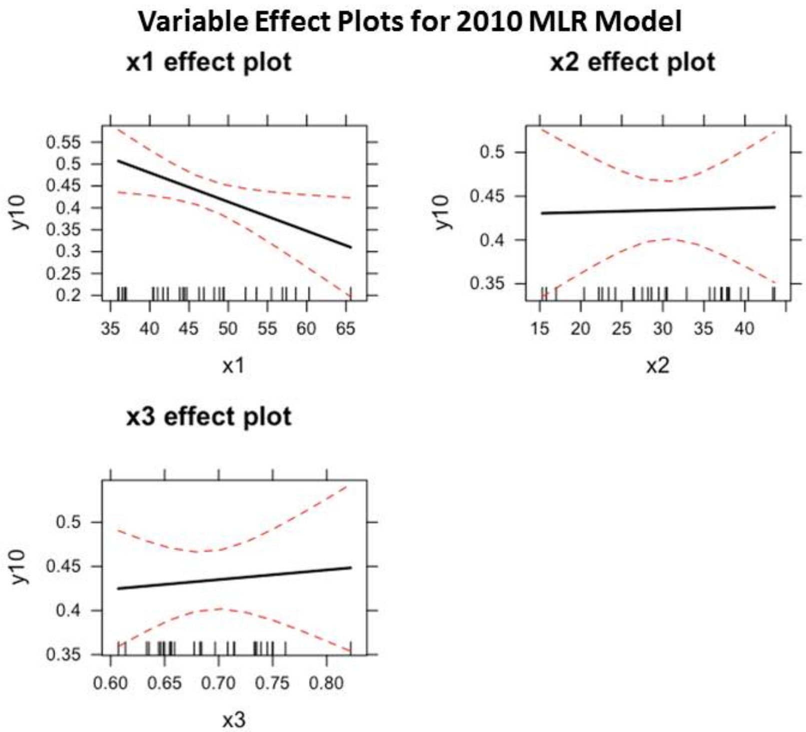

Figure 2.5: Effect display for 2010 MLR model described in text following Fox and Weisberg (2010). Variable names follow convention described in text.

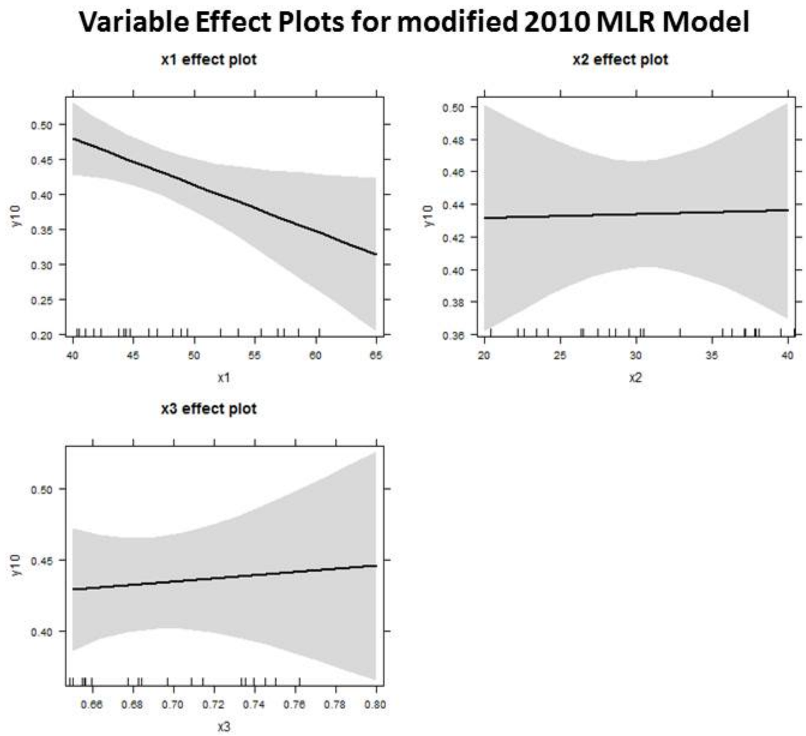

Figure 2.6: Effect display for modified 2010 MLR model with X1 as 2012 election results instead of 2008 results.

CHAPTER 3

STATES, WATER, AND CLIMATE

Twenty-nine states have developed formal water plans to guide their future water supply and demand management and investments. Typically, these plans make both assessments and projections of current and future water demand and supply. The projections typically account for population, demographic, and economic changes anticipated by the state. Some states also consider the impact of a changing climate on their water supply and/or demand. The previous study (Chapter 2), explored the drivers for state-level policy preferences related to climate change. This study explores the drivers for state government policy choices, specifically regarding water resource management as represented by the state water plans. Independent variables representing vulnerability and political preferences will be tested as drivers of the choices made by states to either incorporate or not to incorporate climate change science into their state water plans. These results will be compared to a similar analysis with the state hazard mitigation plans to test for consistency or differences in how states approach planning for different resources.

3.1 Theory

Scholars have shown that risk perception (e.g., O'Connor et al., 1999), ideology (e.g., McCright & Dunlap, 2011), and vulnerability (e.g., Brody et al., 2008) are predictors for individual policy choices related to addressing climate change. In Chapter 2, I found that ideology or partisan political preference is the major predictor for policy preferences related to addressing climate change at the state-level using data aggregate and other state-level data. This study tests for predictors of policy preferences at the state-level as represented by state water and hazard mitigation planning documents. Do state governments represent the majority opinion of their constituents in developing plans to address or not address climate change? Are there other predictors related to vulnerability or experience with hazards that come into play in predicting state planning documents?

Broadly, previous research has found coherent relationships between policy preferences of constituents and the policy choices of their elected government. Page and Shapiro (1983) and Monroe (1998) both examined this relationship using survey data to represent constituent policy preferences and analysis of policy choices of the US government. As expected, Page and Shapiro found general congruence between changing public opinion and policy choices of the government. Monroe found a somewhat less consistent relationship between majority opinion and policy choices. Both studies found stronger congruence in policy areas most important to voters and less congruence in relatively obscure policy areas of less interest and visibility to voters and in policy areas such as campaign financing that directly impact politicians. Water policy tends to be somewhat obscure so long as the public does not feel threatened (Gleick, 1998). Thus, one might expect governments to make policy choices that respond more to vulnerabilities than to political preferences of voters if the two areas are at odds.

Although addressing climate change in state water planning has not been studied systematically, scholars have examined water planning efforts at different scales. Feldman (2013) for example, described water planning efforts to address climate change at different scales ranging from very local to global. He described planning efforts in Brazil where climate scientists were connected directly with farmers in the Amazon River Basin to promote the co-creation of scientific data for farmers to apply to their decision making. He also described planning efforts at the city level in Los Angeles and Tokyo to address climate change and noted that these efforts have already demonstrated some success. In Los Angeles, for example, total water demand is about the same in 2013 as in 1980 even though there has been has increase of over a million people.

Outside of water planning specifically, scholars have also studied the use of climate change science in state planning efforts for hazard mitigation. For example, Babcock (2013) examined the State Hazard Mitigation Plans that each state in the US is required by the Disaster Mitigation Act (DMA) to produce in order to be eligible for FEMA funding following a disaster. Each plan was assessed for its treatment of climate change using objective analysis techniques such as the presence of a climate change section and subjective techniques such as assessing the accuracy of any climate change content. States were assigned a one to four ranking characterizing their treatment of climate change. Category one meant there was no discussion of climate change or the discussion was inaccurate. Category four meant there was a “thorough discussion of climate change impacts on hazards and climate adaptation actions” (Babcock, 2013, p. 5). Babcock used these rankings to draw qualitative conclusions on the relative importance placed on climate change in assessing future hazards in the state planning efforts. Among other things, he found that coastal states have addressed climate change in their plans to a greater extent than landlocked states. This was partially explained by the increases in sea level and greater exposure to coastal hazards such as storm surges. Both have increased in recent years and are expected to further increase in future years.

Other scholars have taken a broader approach to studying hazard mitigation and emergency plans. For example, Berke, Smith, and Lyles (2012) evaluated the overall quality of each of the coastal states' hazard mitigation plan. They evaluated the plans based on six principles articulated in the DMA: goals, fact base, mitigation policies, implementation and monitoring, interorganizational coordination, and participation. The plans were scored using content analysis and the six criteria. The authors found the overall quality of state hazard mitigation plans to be moderate to low. They speculated that the variance between state's scores might be explained by, among other variables, experience with recent disasters or vulnerability to future disasters. Although Berke, Smith, and Lyles (2012) did not explicitly address the topic of climate change, nor did they test any of their possible explanations of the state-to-state variance, they did suggest that changing vulnerabilities may be a factor in predicting plan scores.

Water planning at the state level and state water plans, in particular, have not received the same level of attention as hazard mitigation or emergency planning. In general, water resources planning has relied on engineering approaches in its planning of water resources infrastructure projects, estimating expected or known water demands based on historical data for water supplies such as precipitation and stream gage records (e.g., Dunne and Leopold, 1978). However, these traditional planning efforts do not typically account for the potential impact of climate change on water supplies or demands. Snover, Hamlet, and Lettenmaier (2003) described the potential for climate change scenarios to inform water planning efforts at the local levels. More recently, Gober et al. (2010) documented the need for water management agencies to incorporate climate change impact scenarios especially in the semiarid southwestern US where climate change is expected to diminish an already scarce water supply. Indeed, in recent years, major agency water studies have started to incorporate climate change scenarios (e.g., Prairie & Jerla, 2012).

At the same time, scholars have examined water availability and vulnerabilities of water supply systems. For example, Padowski and Jawitz (2012) examined the water supplies of America’s 225 largest cities for current and future availabilities. They concluded that the supplies, particularly in the southwestern US, are at risk as climate and population patterns change. Similarly, Averyt et al. (2013) examined stress on surface water supplies both presently and in the future, and concluded that the southwestern US was particularly at risk. The recent third national climate assessment (Melillo, Richmond, & Yohe, 2014) synthesized this literature and concluded that the key message for climate change impacts in southwestern US was that there will be reduced streamflows and a reduced snowpack in the region. In the northwestern part of the US, the key message was also water-related challenges but in a different direction.

At the state-level, state water plans have increasingly been adopted mostly by western states in the US to plan for their future water needs. Currently, a majority, 29, states have adopted water plans. These plans have not been systematically studied by scholars the way that hazard mitigation plans have. Perhaps this is because comprehensive water planning at the state-level is generally (with significant exceptions) speaking a more recent and more varied phenomenon than water planning at the project level, or hazard mitigation and emergency planning at the state-level. Nonetheless, state water plans articulate state policy preferences around an important resource issue and are, therefore, a worthy target for research. Of particular interest here are the assumptions that go into future water supply and demand scenarios for which states plan. Future water supply scenarios traditionally assume past supplies will be available in the future. Future water demand scenarios are traditionally based on population and/or economic scenarios, particularly for agriculture as it uses the vast majority of water across western states. Climate change assessments focusing on water resources, however, have projected with increasing confidence that water supplies will change as the climate continues to change (e.g., Georgakakos et al., 2014). Water supplies in some places like the American southwest will diminish while they may increase in others. Furthermore, these assessments suggest that water demand will also change as a result of the changing climate; as temperatures increase, there will be increased demand for water for cooling and for agriculture as more water evaporates. To what extent these projected changes are being accounted for in water plans and understanding what motivates some states to account for these changes more so than others are important questions for practitioners and scholars alike. This study tests those motivations with the following hypotheses:

- H3.1: States will account for the impacts of climate change on their water resource portfolio (h_1) based on the vulnerability of those resources to a changing climate (v_1), public support for adopting policies to adapt to a changing climate (v_2), and elected officials' support for adopting policies to adapt to a changing climate (v_3). This is represented as follows:

$$h_1 = (v_1 + v_2 + v_3) + E \quad (3.1)$$

The dependent variable is the degree to which climate change is addressed by the state water plan. Independent variables considered are vulnerabilities of water resources to climate change, the partisan election outcome in each state, and public support for climate change policy. The latter was the dependent variable in the prior study (presented in Chapter 2).

To provide a comparison with the state hazard mitigation planning realm, I further hypothesize that:

- H3.2: States will account for the impacts of climate change on their hazard mitigation portfolio based on trends in disasters (h_2), public support for adopting policies to adapt to a changing climate (v_2), elected officials support for adopting policies to adapt to a changing climate (v_3), and number of recent disasters (v_4).

$$h_2 = (v_2 + v_3 + v_4) + E \quad (3.2)$$

3.2 Methods and Data

Ordinal logistic regression modeling is used to test the relationships between the dependent variables (e.g., degree to which states address impact of climate change on water plans and hazard mitigation plans) and the independent variables considered in this study. Data are drawn from a number of sources as well as developed from content analysis.

Data for the dependent variable, h_1, were drawn from a content analysis of state water plans. These plans were downloaded directly from the states that have them. Of the 29 states with water plans, 20 have produced an updated plan within the past five years. These plans vary in complexity and detail. Plans range from less than 100 pages in length to well over 1,000 pages. The plans also vary in their content. Most plans make quantitative assessments of current water usage, water demand, and water supply as well as projections of future water demand and supply. Table 3.1 provides information on the state water plans used in this study.

Many states also have drought plans and they were initially considered as a potential data source for this study. However, after initially analyzing several drought plans, it became apparent that these plans were much less current and much more process focused than the water resource plans. Many of the state drought plans were more than 1 or 2 decades old, making them less likely to address climate change issues simply based on when they were written. Furthermore, unlike state water plans, which generally include quantitative outlooks and assessments of variables related to climate change, drought plans mostly focus on the decision-making process for the state to declare a drought.

In order to compare results between the state water plan hypothesis (h_1) and the state hazard mitigation plan hypothesis (h_2), Babcock's (2013) four category content analysis procedure was applied to the state water plans to assess the degree to which climate change is accounted for in the plan. Babcock's (2013) study also included descriptive data on attributes of the state hazard mitigation plan including publication year, source, summary, summary of climate change presentation, mentions of climate change adaptation, etc. The state water plans in this study were also coded for this kind of descriptive data. Although Babcock's analysis was not as rigorous as other evaluations of state hazard mitigation plans (e.g., Berke et al., 2012), its focus on addressing impacts of climate change and its relatively simple methodology lent itself to replication here.

A coding scheme was developed based on the methodology described by Babcock (2013). This scheme is included in the Appendix. The coding scheme was tested independently by three coders on four state hazard mitigation plans randomly chosen from each of Babcock's four categories. The results of the intercoder reliability test are shown in Table 3.2. Of the 12 coding attempts, 9 of the categories assigned matched those assigned by Babcock (2013). The three coding mismatches or "discrepancies" pertained to states that Babcock (2013) had assigned a category of two or three, and those "discrepancies" were only one category off from Babcock's designation (e.g., the category assigned by the coder was only one level different from what Babcock has assigned). The overall error rate was 3/12 or 25% but the coding for the extreme categories (one and four) was perfect. This error rate translates to an overall percentage agreement rate of 75%, which is within the range of 70% to 97% of intercoder reliability for state plan evaluations reported by others (Berke & Godschalk, 2009).

The coding scheme was then applied to the 29 water plans in order to assign categorical rankings to each water plan. Those rankings are reported in Table 3.3 together with Babcock's (2013) rankings of the state hazard mitigation plans. The results of both rankings are also presented geographically in Figure 3.1 (state hazard mitigation plan rankings) and Figure 3.2 (water plan rankings). The correlation coefficient between the two rankings for the 29 states that have both plans is 0.51.

Data for independent variables are drawn from multiple sources. Constituent support for policies to address climate change (v2) is drawn from the Pew survey data used in Chapter 2 (Pew, 2007, 2010). As in Chapter 2, these data are aggregated to the state-level. Voting data (v3) are drawn from the Federal Elections Commission dataset used in Chapter 2 (FEC, 2012). Also following Chapter 2, disaster data comes from FEMA (FEMA, 2011).

Nationally consistent data on state water resources availability and water resource vulnerability (v1) to climate change is not readily available. Recognizing this challenge, Congress in 2009, through the SECURE Water Act, directed the US Geological Survey to conduct a "national water availability and use assessment program" that would, among other things, "provide a more accurate assessment of the status of the water resources of the US" (USGS, 2015). Unfortunately, these data do not yet exist, requiring a different approach for obtaining data for v1. Of course, the state water plans themselves often provide this assessment. However, as described previously, the plans vary greatly in their level of detail and the manner in which they describe current and future water availability. Furthermore, since those plans are the focus of this study and the data from which the dependent variable is drawn, it would not be appropriate to use them to also define the independent variables. Instead, to obtain consistent data independent from the state water plans on a national scale, I turn to two sources: (1) Padowdki and Jawitz's (2012) study of the water resources availability and vulnerability for the nation's 225 largest cities, and (2) the 2014 National Climate Assessment (Melillo et al., 2014).

Padowdki and Jawitz (2012) assessed both current and future water supplies relative to demand for the 225 largest cities in the US. They considered surface water supplies including streams, major rivers, lakes, and reservoirs as well as groundwater to develop a water availability index with a value for each of the 225 cities. They then assessed the water demand based on populations and use patterns to make a categorical assessment of each city's future vulnerability. To overcome the lack of nationally consistent water resources data, this study relied on a number of assumptions to develop its availability index. Significantly among these are the following: the inability to represent the intricacies of the water management infrastructure, including water transfers between rural, agricultural, and urban entities.

Nonetheless, the Padowdki and Jawitz (2012) water availability index is consistent across the country. I utilized this index to create a statewide index by averaging the availability values from the cities in each state to create a state availability index. This index is plotted in Figure 3.3. In addition to the limitations of the Padowski and Jawitz (2012) city index, this index has at least two more important limitations: first and foremost, this index does not reflect agricultural or rural water resource availability. In most states, those water uses are larger than the urban water uses. However, at a state or regional level, water resources availabilities and particularly vulnerabilities are broadly consistent. Second, states have widely differing numbers of the 225 urban areas within their boundaries. Some states (e.g., Wyoming) do not have any urban areas whereas others have many (California alone has thirty). Given these limitations, the state-level data derived from Padowdsi and Jawitz (2012) will be used cautiously in considering water availability at the state-level. That said, this index does present a regionally appropriate picture of water availability with the least availability in the semiarid southwestern US – especially Arizona, New Mexico, and Utah; and the greatest availability in the Gulf Coast states, the midwest, and the Pacific northwest. At least at that level, this dataset accurately reflects regional patterns of water availability lending support for its use in this study.

The second study used to inform analysis of state water availability and vulnerability at the state level is the third National Climate Assessment; in particular, the chapter on water resources (Georgakakos et al., 2014). Although the National Climate Assessment does not provide state-level data, it does provide an assessment of the regions where water resources are expected to be most impacted by climate change. Figure 3.4, for example, shows the major river basins in the western US and the expected changes in their discharge resulting from three climate change scenarios. The major rivers in the southwestern US are expected to see dramatic declines in streamflow, while those in the northwest are expected to see increases. While the magnitude of change is dependent on the climate change scenario, the direction of change (e.g., increase or decrease) is consistent across the scenarios. While these data are not available at the state level, the general pattern of southwestern states expected to experience a declining water resource with climate change will be used to inform a qualitative discussion about southwestern states and how they address climate change in their water plans.

Figures 3.5 and 3.6 show the independent variables used in this study as a function of the dependent variables (WP rankings in Figure 3.5 and SHMP rankings in Figure 3.6).

3.3 Models

The following ordinal logistic regression models are used:

$$h_1 = (v_1+v_2+v_3) + E \tag{3.3}$$

$$h_2 = (v_2+v_3+v_4) + E \tag{3.4}$$

Ordinal logistic regression models which were chosen as the dependent variables in both cases are ordered categorical variables with no defined zero and no consistent interval between defined categories. In both the water plan (Equation 3.3) and state hazard mitigation plan (Equation 3.4) models, data are available and used for the entire population. This means that probability sampling methods are not necessary.

For water plans (Equation 3.3), the model was run with only 26 states that have both water plans and a water availability index. For the state hazard mitigation plans (Equation 3.4), the model was run for all 50 states. Many permutations to the model were tested including running them on subsets of the states, using somewhat different representations for variables, and including different variables altogether in order to test for consistency of results. The models reported here utilize the 2010 Pew survey results for v_2 and the 2012 presidential vote for v_3. Similar results were reported when the model used the 2008 presidential vote for v_3 or the 2007 Pew survey results for v_2. Similarly, additional models were tested with other independent variables used in Chapter 2 but none of these independent variables were found to be significant.

I also used ordinary Multivariate Linear Regression (MLR) models similar to those used in Chapter 2. While the MLR model results were more straight forward to interpret, the ordered categorical nature of the dependent variables make the ordinal logistic models a more appropriate (and conservative) choice for this study.

3.4 Results

Ordinal logistic regression model results for the water plan model are reported in Table 3.4 and for the state hazard mitigation plan model are shown in Table 3.5. For the water plan model (Equation 3.3), regression coefficient values (B estimate) for the Rep2012 and Avail variable are similar to their corresponding standard error estimates indicating significant relationships. For Rep2012, the -5.39 B estimate indicates that a 1% increase in vote for the Republican presidential candidate reduces the log odds of incorporating climate science into the state water plan by 5.39. Similarly, for water vulnerability, the 0.38 B estimate indicates that 1% increase in water availability reduces the log odds of incorporating climate science into the state water plan by 0.036. Interestingly, for public opinion, the standard error estimate is much greater than the B estimate indicating that this variable is much less significant in predicting the water plan ranking. The model confidence intervals provide another estimate of the relative importance of the independent variables. Independent variables whose confidence intervals do not cross zero are considered insignificant. For the water plan model (3.3), Rep2012 is the only independent variable that intersects zero. Since the model utilizes the full population of state-level data, the *p* values reported are not as indicative of significance as they would be in a study using a data sampling strategy such as that in Chapter 2. Therefore, I conclude that the Republican vote and the water availability are both significant predictor variables for the water plan rankings (e.g., the 1-4 rankings described earlier).

For the state hazard mitigation plan model (3.4), Rep2012 independent variable emerges as the most significant predictor variable. Its regression coefficient (B estimate), -15.62, is much greater than its standard error (4.02) and its confidence interval is very narrowly centered near zero. The standard errors for the other two independent variables in that model are much greater than their regression coefficient and their confidence intervals do not intersect zero. Therefore, I conclude that the state Republican vote is the only significant predictor variable for the state hazard mitigation plan rankings.

The similarities between the water plan model results and hazard mitigation model results are striking. Although the models included different independent and dependent variables as well as different configurations of states, both models showed the presidential vote as a significant predictor variable for the state water and hazard mitigation plans.

These results are consistent with a qualitative inspection of the states in the region most at risk of reduced water supplies as reported by the Climate Assessment (Georgakakos et al., 2014). This region is the southwestern US (e.g., Figure 3.4). This region includes Arizona, New Mexico, Utah, and Nevada, which are all states with a water plan ranking of one, meaning they did not account for climate change at all in their water plans. However, this region also includes California, Colorado, and Oklahoma. These are states which have a water plan ranking of four. Similarly, in regions with less risk to their water supply decreasing, as a reported impact of climate change in the National Climate Assessment, there are states that span the four rankings for water plans.

This qualitative analysis is consistent with the water plan ordinal logistic regression model showing a significant relationship with the presidential vote, but apparently, also at odds with the model result showing a significant relationship with water availability/vulnerability.

Recall the hypotheses presented in this study, H3.1 and H3.2, predicted that states would incorporate climate change projections in their water plans (H3.1) and hazard mitigation plans (H3.2) based on the vulnerability of those resources to a changing climate (v1 and v4), public support for adopting policies to adapt to a changing climate (v2), and elected officials support for adopting policies to adapt to a changing climate (v3). These results require the partial rejection of both hypotheses, H3.1 and H3.2. Of the three variables hypothesized to be significant predictors for each of the dependent variables, only the policy preferences of elected politicians, (imperfectly) represented by the presidential election results variable and the water availability variable were significant.

3.5 Conclusions

A speculative conclusion to be drawn from these results is that state plans (both for water and hazards) respond more to the political party of elected politicians (as reflected by the presidential vote) than they do to the policy preferences of the people or the vulnerability of the state to the natural phenomena of interest. Clearly, there are exceptions to this (e.g., Oklahoma's water plan ranking of four). I also again emphasize that this study does not perfectly represent any of the variables. Nonetheless, this study suggests additional data and analysis on both the impact of elected political leaders at the state-level, on their planning efforts as well as the apparent lack of impact of the changing climate, and the policy preferences of the state constituents would all be fruitful avenues to pursue. Additionally, as the rate of climate change increases and impacts to water resources become more apparent, particularly in the southwestern US, the management and planning efforts of those states should be followed to assess when and how there are changes that are responsive to the emerging realities of reduced water resources in that region.

Although the contents of the water plans themselves are apparently less driven by a state's vulnerability to shortages in water resources, the existence of a water plan might be. As noted earlier, western states are far more likely to have a water plan than are eastern states. This pattern follows qualitatively the regions that are currently experiencing the greatest challenges with water supply. The southwestern states have dealt with the semiarid climate that has existed throughout their history. As water demands have grown during the 20th century, these states have a history of making difficult decisions to balance water supply and demand. The southwestern states are also most at risk for reductions in water supplies and challenges with water resources as described by the National Climate Assessment. Furthermore, within the western US, states with no plan (e.g., Washington) or older plans (e.g., Idaho), tend to be northern states with less risk of reducing water supplies than their southern counterparts. Perhaps vulnerability (v1), therefore, is a predictor for the existence of a water plan more than the contents of a water plan.

These results are relevant for the water resources practitioner who often views his or her work as separate from the political world. As water resources agencies continue to grapple with meeting the challenges imposed by climate change, these results suggest that they will also have to meet the challenges imposed by the political system they operate within and, in particular, the policy preferences related to climate change of the political leadership they serve. Should Republican states continue to not incorporate climate change into their planning efforts, this will add an important obstacle for water resource planners charged with ensuring their constituents will have reliable sources of water into the future.

Table 3.1: State water plans used in study

State	Plan Name	Link	Year Latest Plan Published
AL	MAPPING THE FUTURE OF ALABAMA WATER RESOURCES MANAGEMENT: Policy Options and Recommendations	http://adeca.alabama.gov/Divisions/owr/awawg/pages/default.aspx	2014
AK			
AZ	Arizona's Next Century: A Strategic Vision for Water Supply Sustainability	http://www.azwater.gov/AzDWR/Arizonas_Strategic_Vision/	2014
AR	Arkansas Water Plan	http://arkansaswaterplan.org/	2014
CA	California Water Plan	http://www.waterplan.water.ca.gov/	2013
CO	Colorado Water Plan	http://coloradowaterplan.com/	2014
CT			
DE			
FL	Florida Water Plan	http://www.dep.state.fl.us/water/waterpolicy/fwplan.htm	2013
GA	Georgia's State Water Plan	http://www.georgiawaterplanning.org/	2008
HI	Hawaii Water Plan	http://dlnr.hawaii.gov/cwrm/planning/hiwaterplan/	2008
ID	State Water Plan	http://www.idwr.idaho.gov/waterboard/WaterPlanning/Statewaterplanning/State_Planning.htm	2012
IL			
IN			
IA	Iowa Water Plan	http://www.iowadnr.gov/Environment/WaterQuality/IowaWaterPlan.aspx	2007-2012
KS	Kansas Water Plan	http://www.kwo.org/Kansas_Water_Plan/KansasWaterPlan2014.html	2014
KY			
LA			
ME			
MD			
MA			
MI			

Table 3.1 Continued

State	Plan Name	Link	Year Latest Plan Published
MN	2010 Minnesota Water Plan	https://www.eqb.state.mn.us/sites/default/files/documents/2010_Minnesota_Water_Plan.pdf	2010
MS			
MO	Missouri Water Plan	http://www.dnr.mo.gov/env/wrc/statewaterplanmain.htm	various
MT	Montana State Water Plan	http://www.dnrc.mt.gov/wrd/water_mgmt/state_water_plan/	2015
NE			
NV	Nevada State Water Plan	http://water.nv.gov/programs/planning/stateplan/	1999
NH		http://des.nh.gov/organization/divisions/water/dwgb/wrpp/index.htm	
NJ	Water Supply Action Plan	http://www.state.nj.us/dep/watershedmgt/DOCS/pdfs/WaterSupplyActionPlan03-04.pdf	2003
NM	Working Toward Solutions: Integrating our water and our economy	http://www.ose.state.nm.us/Planning/index.php	2013; review of 2003 water plan
NY			
NC			
ND	State Water Management Plan	http://www.swc.nd.gov/4dlink9/4dcgi/GetContentPDF/PB-2519/Water%20Plan.pdf	2015
OH			
OK	Oklahoma Comprehensive Water Plan	http://www.owrb.ok.gov/supply/ocwp/ocwp.php	2012
OR	Oregon's Integrated Water Resource Strategy	http://www.oregon.gov/owrd/pages/law/integrated_water_supply_strategy.aspx	2012
PA	State Water Plan	http://www.pawaterplan.dep.state.pa.us/statewaterplan/docroot/default.aspx	2009
RI	Rhode Island Water 2030	http://www.planning.ri.gov/statewideplanning/land/water.php	2012

Table 3.1 Continued

State	Plan Name	Link	Year Latest Plan Published
SC	South Carolina Water Plan	http://www.dnr.sc.gov/water/waterplan/index.html	2004 With an assessment in 2009
SD	State Water Plan	https://denr.sd.gov/dfta/wwf/statewaterplan/statewaterplan.aspx	2013
TN			
TX	Water for Texas	https://www.twdb.texas.gov/waterplanning/swp/	2012
UT	Utah Water Resources: Planning for the Future	http://www.water.utah.gov/waterplan/SWP_pff.pdf	2001
VT			
VA	State Water Plan	http://www.deq.virginia.gov/Programs/Water/WaterSupplyWaterQuantity/WaterSupplyPlanning/StateWaterPlan.aspx	2014
WA			
WV	State Water Resources Management Plan	http://www.dep.wv.gov/WWE/wateruse/WVWaterPlan/Pages/default.aspx	2013
WI			
WY	Leading the Charge	http://waterplan.state.wy.us/	2015

Table 3.2: Intercoder Reliability Test. Coding schema test results from three independent coders on four state hazard mitigation plans and comparison to categories assigned by Babcock (2013).

State	Babcock	Coder 1	Coder 2	Coder 3
WY	1	1	1	1
NH	4	4	4	4
NJ	3	3	4	4
OH	2	2	2	3

Table 3.3: Cross tabulated rankings for state hazard mitigation plans (from Babcock, 2013) and state water plans

SHMP -> WP	1	2	3	4
1	GA, MO, NV, NM, ND, SD, WY	AZ, ID, IA, UT, VA	FL, NJ	
2	AL	KS, SC, TX	WV	
3	MT	AR, PA	MN	HI
4	OK		OR, RI	CA, CO

Table 3.4: Ordinal logistic regression model results for water plan model (h_1). *B* estimates are the regression coefficients, *SE* are the standard errors, *t* are the t-test values, *OR* are the odds ratios, and *CI* are the confidence intervals.

Variable	*B*	*SE*	*t*	*OR*	*CI*(2.5%)	*CI*(97.5%)
Romney 2012 (v_3)	-3.04	4.63	-0.657	0.048	0.00	417
Water availability (v_1)	0.030	0.30	1.03	1.03	0.98	1.09
Public support (v_2)	1.80	3.27	0.534	6.04	0.08	4460
N = 26 (full population)						

Table 3.5: Ordinal logistic regression model results for state hazard mitigation plan model (h_2). *B* estimates are the regression coefficients, *SE* are the standard errors, *t* are the t-test values, *OR* are the odds ratios, and *CI* are the confidence intervals.

Variable	*B*	*SE*	*t*	*OR*	*CI*(2.5%)	*CI*(97.5%)
Romney 2012 (v_3)	-15.62	4.02	-3.89	0.00	0.00	0.0004
NDisaster (v_4)	0.005	0.017	0.323	1.01	0.97	1.04
Public support (v_2)	1.86	2.48	0.749	6.40	0.05	8.29
N = 50 (full population)						

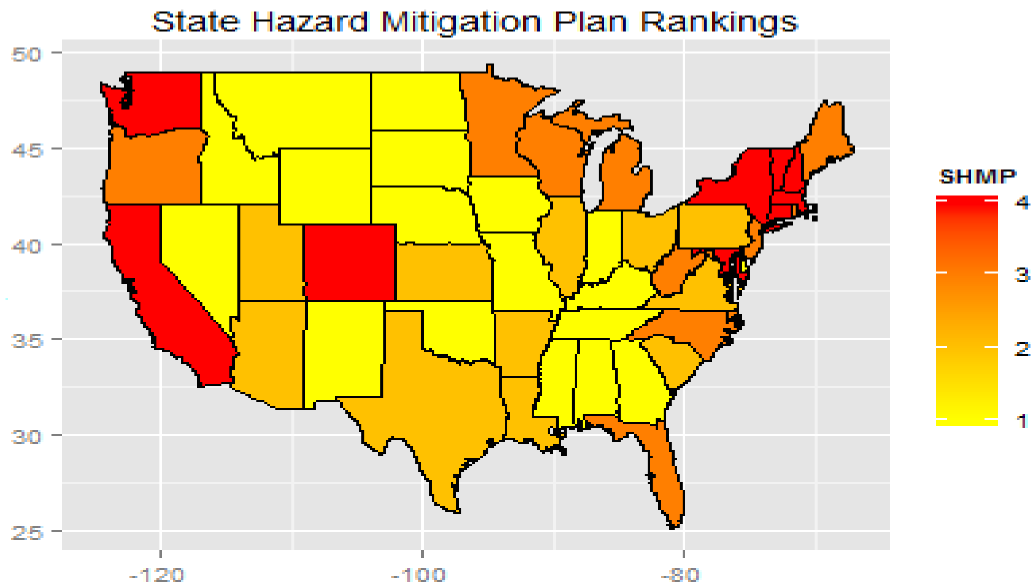

Figure 3.1: State hazard mitigation plan rankings for addressing impacts of climate change (data from Babcock, 2013).

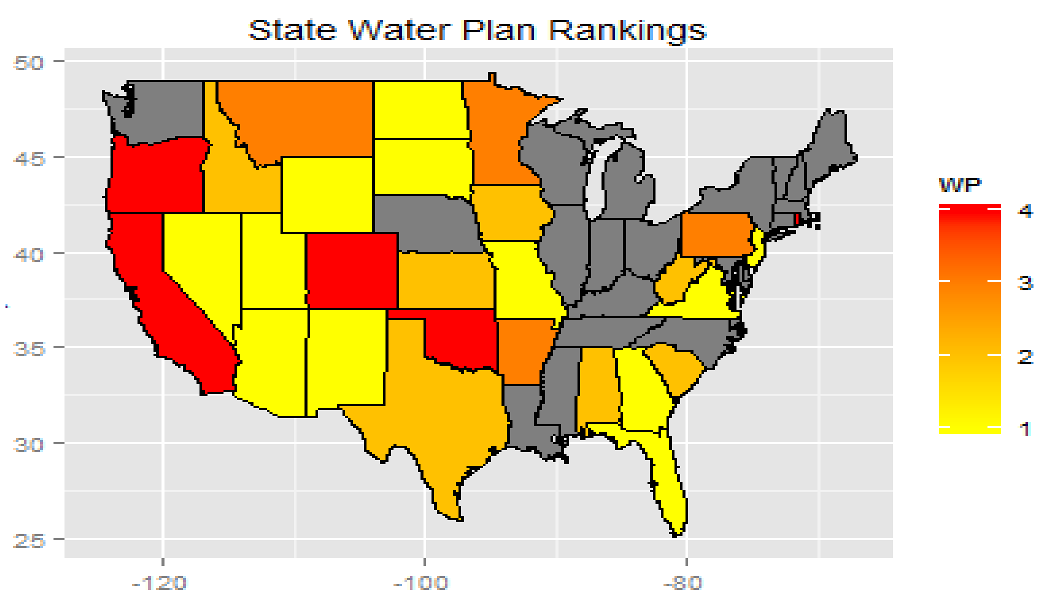

Figure 3.2: Water plan rankings for addressing impacts of climate change.

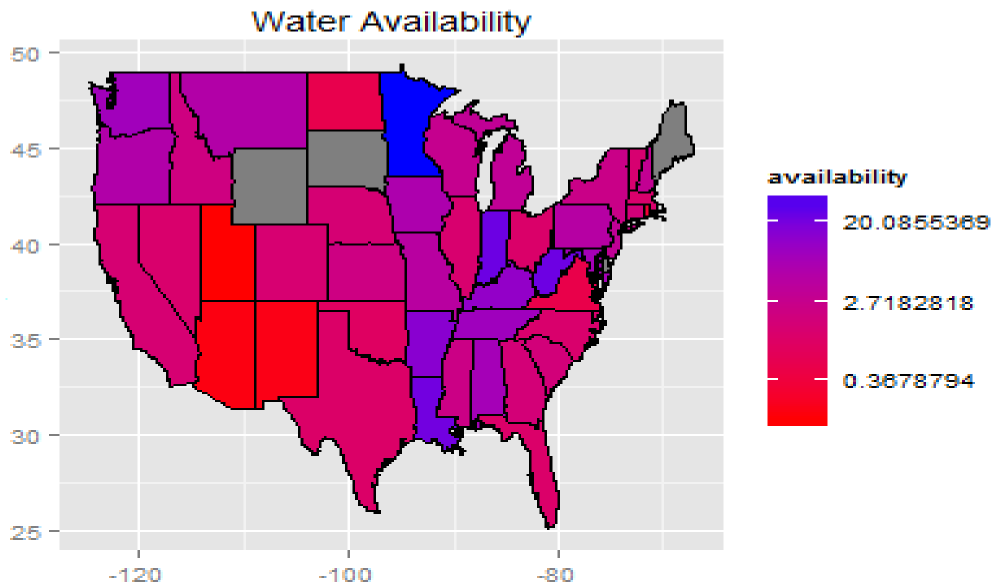

Figure 3.3: State water availability index created from Padowski and Jawitz (2012) city availability index.

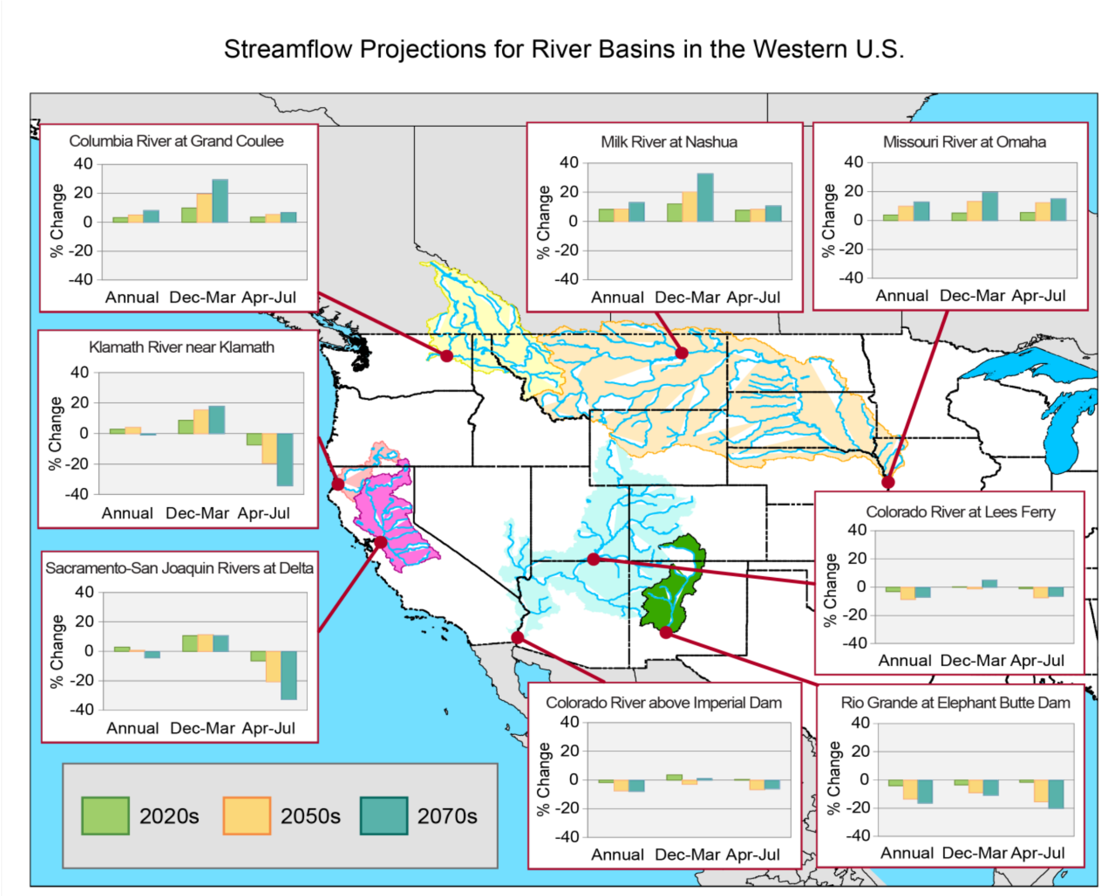

Figure 3.4: Annual and seasonal streamflow projections based on scenarios with substantial emissions reductions, gradual reductions from current emission trends beginning around midcentury, and continuation of current rising emissions trends. Scenarios are for eight river basins in the western US. The panels show percentage changes in average runoff, with projected increases above the zero line and decreases below. Projections are for annual, cool, and warm seasons, for three future decades (2020s, 2050s, and 2070s) relative to the 1990s. Reprinted with permission from USBR (2011) and as it appeared in Georgakakos et al. (2014).

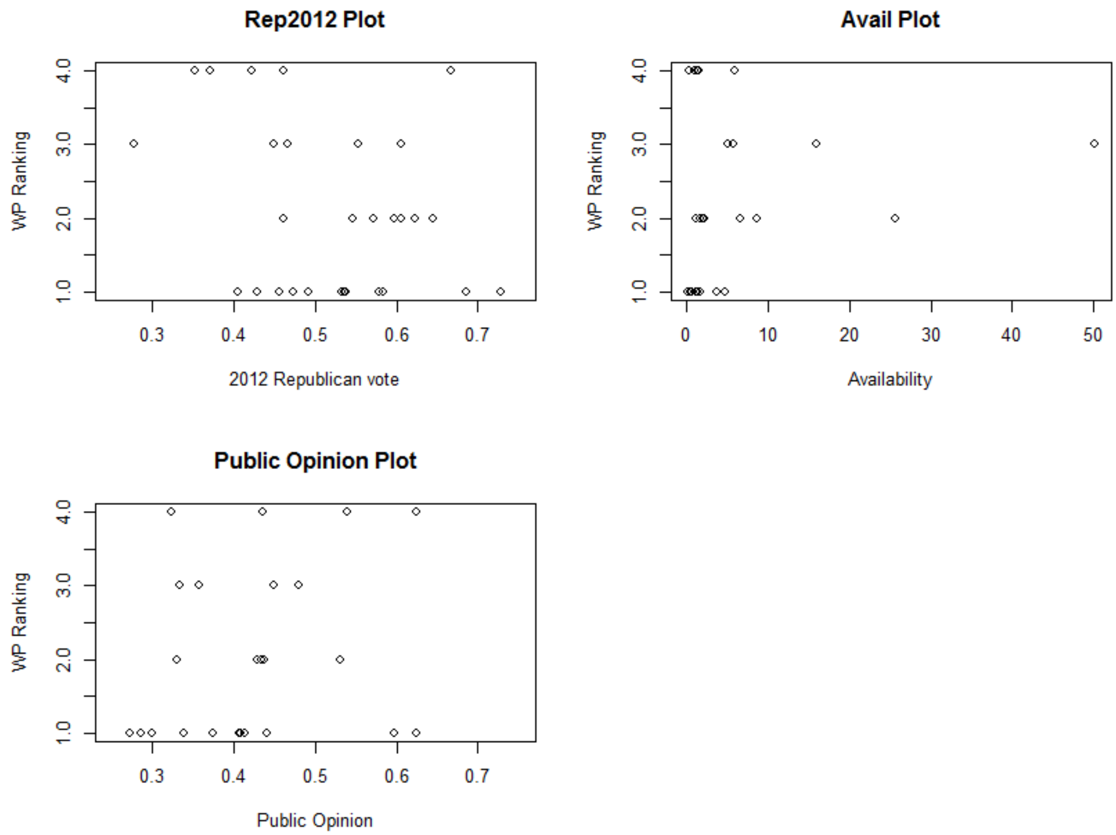

Figure 3.5: State water plan rankings (WP Ranking) as a function of independent variables used in ordinal logistic model: 2012 presidential vote (Rep2012), water availability index (Avail), and 2010 public support for climate change adaptation policies (Public Opinion).

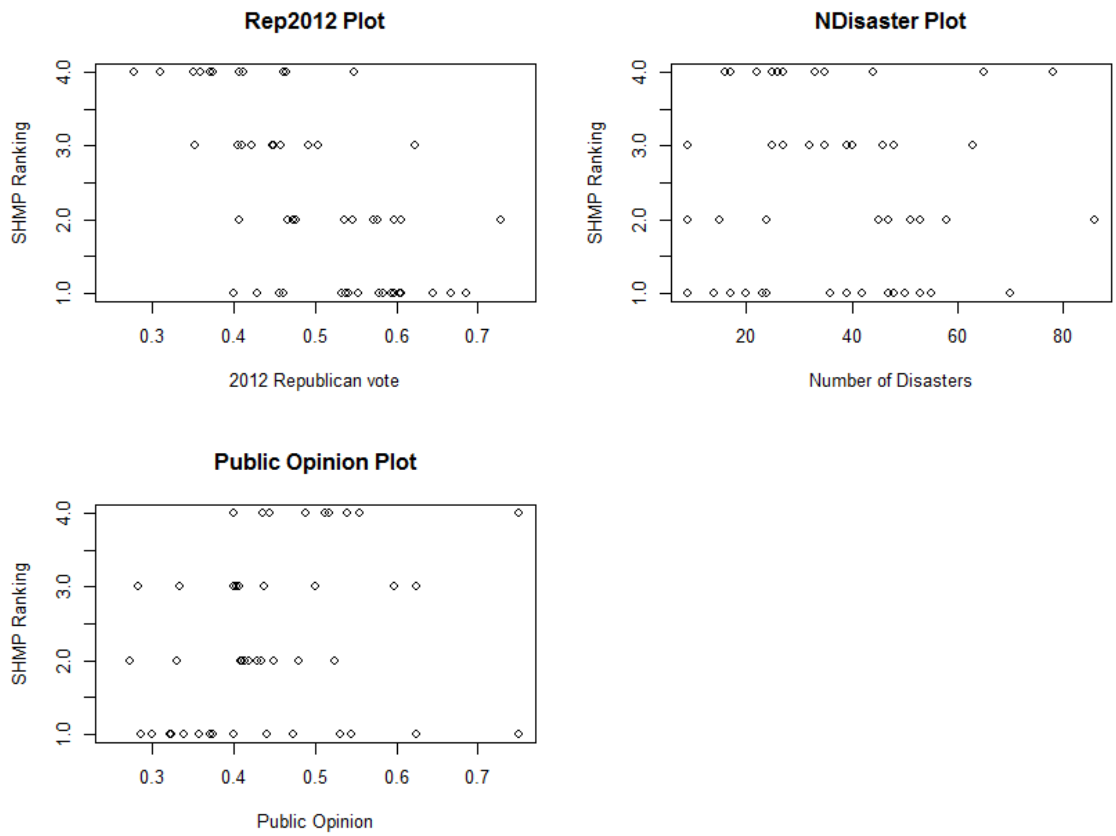

Figure 3.6: State hazard mitigation plan rankings (SHMP Ranking) as a function of independent variables used in ordinal logistic model: 2012 presidential vote (Rep2012), number of disasters (NDisaster), and 2010 public support for climate change adaptation policies (Public Opinion).

CHAPTER 4

TWO BIG STATES; TWO DIFFERENT APPROACHES

Two of the nation's largest states, California and Texas, share recent experience with major drought, growing urban populations, major agricultural industries requiring water supplies, and increasing vulnerability of diminishing water resources due to predicted future climate change. California and Texas both have adopted detailed water plans in 2012 and 2013 and have committed billions of dollars to address these challenges. While they share these similarities, the two states have taken dramatically different approaches to addressing climate change in their water planning. California has addressed climate change head on in its plan through sophisticated scenario development, utilizing the best available science to inform its plans. By contrast, Texas described a single meeting held as part of their planning process to discuss the possibility of climate change adversely affecting its water supply and noted that further research is required.

The previous two studies, in Chapter 2 and Chapter 3, have shown a relationship between state voting records and state preferences for policies mitigating or adapting to changing climate. States with larger percentages of votes for the Republican presidential candidate are less likely to address climate change in their state plans for water and hazard mitigation (Chapter 3). Furthermore, citizens within those states are less likely to prefer policies to address climate change (Chapter 2). Other predictors such as the state's vulnerability to drought or natural disasters are not significant predictors of policies that consider climate change in relation to water resources. California and Texas are cases in point with regard to this relationship. Despite their similar experiences with recent drought and vulnerabilities to future change, California has been a steadfast supporter of Democratic presidential candidates while Texas has supported Republican presidential candidates.

This chapter presents a comparative case study analysis of water resources planning in Texas and California to (1) illuminate more deeply how the two states describe and address climate change, and (2) elucidate their philosophies toward risk and addressing uncertainty.

This chapter begins with a discussion on methodology including motivations for the case study approach and case selection. Then, differences and similarities between the cases are outlined, particularly political differences, similarities with recent drought experience, vulnerability to diminishing water resources, demographics, and state government sophistication. Finally, the water plans themselves are compared including a focus on their treatment of risk and addressing uncertainty both for climate change and other inputs to water planning.

4.1 Methodology

The case study method is well suited to this problem as it allows detailed exploration to establish rich explanations (George & Bennett, 2005). It is particularly powerful when combined with other research methods such as the quantitative regression analyses employed in Chapters 2 and 3. Whereas Chapter 3 validated a general hypothesis identifying an independent variable (political preference) predicting the dependent variable (state water plan addressing climate change), this study will delve more deeply into two particular water plans in order to test for finer scale differences in how they describe climate change and what their philosophies are toward risk and uncertainty.

Texas and California were chosen as case studies to further illuminate the impact of their political differences on their water planning particularly given their similarities in size, population, and water issues. Although certainly not identical, Texas and California share many similarities in population, experience with recent extreme drought, vulnerability to climate change, crossing water supply and demand curves, and growing cities. These similarities and differences are further described below.

Following discussion of the independent variables, the water plans themselves are examined in detail particularly for assessing their philosophy of risk and uncertainty both for climate change and for other inputs to the states' water planning including population change and urban growth. This allows for analysis of different approaches to uncertainty to different inputs in order to test if climate change uncertainty is being treated differently from other sources of uncertainty.

4.2 Political Differences

An important difference between Texas and California is their approach to government and politics. One piece of evidence for this difference is their voting records. In presidential elections since 2000, solid majorities (between 53 and 61%) of voters in

California voted for the Democratic candidate. In contrast, solid majorities (between 56 and 59%) of voters in Texas have voted for the Republican candidate (FEC, 2012). In the 2012 election, 60% of California voters voted for President Obama while only 41% of Texas voters did.

Political differences are also evident at the state government level. Figure 4.1 shows the partisan composition of the state legislature since the National Conference on State Legislatures began archiving data in 2009 (NCSL, 2015). In California, Democrats have held solid majorities in excess of 60% in both houses of the state legislature. In the same period, Democrats have also held all state wide offices including the governorship. California is currently one of only six states where Democrats have control of the state legislature and the governorship. In Texas, the situation is essentially reversed. Republicans have dominated the state legislature with solid majorities there. They also control the governorship making Texas one of 23 states where Republicans control the state government. These differences are important because state water planning occurs at the state government level. Elected leaders from these parties – particularly the governor and the state legislatures – have considerable power in appointing state agency leaders who, in turn, are responsible for state water planning efforts. Although much of the water planning effort is technical in nature, political considerations may also influence water plan content and approaches. As Chapter 3 demonstrated, this is particularly true as it relates to incorporating climate change into the planning effort. In Texas, where Republicans dominate the state political institutions, there is likely to be an aversion to incorporating climate change projections into planning whereas in California, there is likely to be an insistence on it. The idea that political parties at the state-level well represent the political opinions of their states with the Democratic party to the left ideologically is consistent with previous studies (e.g., Erikson, Wright Jr., & McIver, 1989).

Another piece of evidence of the political differences between the two states is the opinion pieces in the popular media that describe and/or advocate for the political environment in one state. For example, economist Tyler Cowen (2013) opined that the “Texas model” that includes reducing regulation, reducing government’s influence, and reducing taxes is increasingly becoming a goal for the nation at large. *Texas Monthly* senior editor Erica Grieder (2014) published a book entitled *Big, Hot, Cheap, and Right: What America Can Learn From the Strange Genius of Texas* where she agreed with Cowen’s premise. Both Cowen and Grieder include comparisons with California noting the recent migration patterns have included more Californians moving to Texas than vice versa. They characterize many of these migrants as economically motivated people who are lured by lower housing costs, better economic opportunities that exist, at least in part, because of the more limited government and lower tax burden in Texas.

California’s defenders, meanwhile, have noted that California’s economic numbers have recently turned from downward to upward due, in part, to political leadership (Vauhini, 2015). They also note that California, although the cost of living is more expensive, has higher incomes and remains the nation’s center for technology innovation. California’s defenders attribute some of this to California’s regulatory environment which protects the environment and has begun to address climate change (Pavley, 2006).

4.3 Similarities

4.3.1 Recent drought

Texas and California have arguably experienced the worst two droughts in the nation between 2010 and 2015. One consensus approach to describing drought is the interagency US Drought Monitor (Svoboda et al., 2002). The US Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the US Department of Agriculture, and the National Oceanic and Atmospheric Administration. This tool depicts drought spatially over the US using a four category ranking system. The worst category, D4, is used for areas for drought related data (e.g., precipitation, snowpack, river flow, etc.) in the bottom two percentile of their historic values. Put another way, the D4 category shows areas experiencing the worst drought expected in a 50-year period of record. Texas's most recent drought culminated in 2011 with the drought monitor showing its most extreme category, D4, over most of the state (Figure 4.2). This drought caused widespread reductions in water supply especially for agriculture although cities and towns were also impacted with some smaller towns actually trucking in water as their local supplies were depleted.

California's ongoing drought began in 2012 and is continuing at least through 2015 with most of the state experiencing D4 conditions by 2015 (Figure 4.3). This drought was particularly extreme in 2014 with much of the state receiving less than 50% of its average annual precipitation. In 2015, the mountain snowpack, which is critical to water resources in the state, has been at or near record low values. In the midst of these two historic droughts, both California and Texas were drafting their state water plans.

4.3.2 Climate change vulnerabilities

The 2014 National Climate Assessment noted that the southwestern US is at particular risk for diminishing precipitation and water resources as the mean storm track shifts to the north (Georgakakos et al., 2014). Figure 4.4 shows the projected risk index in 2050 for water resources sustainability both with and without climate change. Both scenarios show a dramatic increase in this risk for the southwestern states and California and Texas, in particular. California and Texas share a similar vulnerability to future shortages not just from droughts but also from diminishing long term trends in precipitation as the climate changes.

4.3.3 Growing cities and demographics

The populations of California and Texas are similar in many ways. According to the 2010 census, California has nearly 39 million people, Texas has nearly 27 million (Census, 2011). Both states are growing faster than the national average with Texas growing at 5.2% and California at 2.9%. Proportionately, both states are more racially diverse than the US as a whole – they have the same percentage of Hispanic populations (38.4%) and similar percentages of white populations. They are also younger than the US as a whole. Having said this, there are also relevant and significant differences between the two states. California's higher education rate is higher than the nation's average whereas Texas's is lower than the US average. Texas has a higher rate of poverty than California and the nation. Nevertheless, looking across the categories tracked by the US Census Bureau, we can state that the populations are more similar than they are different.

4.3.4 Water Resource Management

Although they operate differently, both California and Texas have made major investments measured in billions of dollars in water resources. In Texas, the Texas Water Development Board (TWDB) was established in 1957 and is the state agency responsible for state water planning, information, financial assistance to local water agencies, conservation, and the responsible development of water resources (TWDB, 2015). Through its planning efforts, it assesses water needs around the state and makes financial loans to local governments to build and operate water resources infrastructure projects such as reservoirs and canals. TWDB is also the agency responsible for the state water plan. In California, the Department of Water Resources (DWR) was established in 1956, primarily to design, construct, and operate the State Water Project, the largest state built water project in the nation (DWR, 2015). Since then, DWR's mission has expanded to include protection of and planning for the state's water resources as a whole. It is the agency responsible for the state water plan.

Both TWDB and DWR have produced water plans since the late 1950s with updates every 5-10 years. In both cases, the plans assess current and future water resources and make recommendations for addressing deficiencies. In both cases, the recommendations are primarily directed at the state government and are not binding.

Both states are also facing long-term imbalances as demand for water is outpacing supply. Water plans in both states document that the rapidly increasing urban populations are the primary culprits for this change. As the urban populations grow, their need for water increases; at the same time, growing land footprints for urban areas in both states are expected to diminish the amount of irrigated agriculture acres as land use is converted from agriculture to municipalities (the food needs for these growing cities will presumably be increasingly met by increasing imports from outside the state but this is not something considered in either state's water plan).

4.4 Texas's 2012 Water Plan

State water planning in Texas dates back to the 1957 water planning act passed by the state legislature. Since then, there have been nine state water plans, including the 2012 update (TWDB, 2012). Each update has assessed the state's water resources situation both at the time of the plan and projected into the future. The plans also make non-binding recommendations for the state legislature and regional water authorities on how to meet projected demands and changes. In recent years, the state has increasingly relied on and required regional water planning efforts from which the state water plan is increasingly derived. The TWDB has identified sixteen regions within the state for the purposes of this regional planning effort.

The 2012 water plan begins with a letter from the TWDB board chair stating in part that "the primary message of the 2012 State water plan is a simple one: In serious drought conditions, Texas does not and will not have enough water to meet the needs of its people, businesses, and its agricultural enterprises" (TWDB, 2012, p. iii). The plan goes on to describe the economic importance of water for the state and the consequences to the economy should there be insufficient water to meet needs in the future.

Fifty-year projections are made for each of six major water consumer categories: municipal, manufacturing, mining, steam-electric, livestock, and irrigation. These projections rely on population projections from county-level projections made by the

Texas Office of the State Demographer and the Texas State Data Center. The statewide population projection shows a near doubling of Texas's population from 25 million in 2010 to 46 million in 2060 (TWDB, 2012, p. 132). Regional population projections are combined with regional information on water trends within each of the water consumer categories to produce projected water demands for each region and each water consumer category. Aggregated to the state-level, these projections show a near doubling of municipal needs from 4.9 million acre-feet (maf) to 8.4 maf in 2060. Conversely, irrigation needs are projected to decrease from 10 maf to 8.4 maf in 2060. These changes are largely based on the population projections, their impact on converting agricultural land to urban land, and also expected efficiencies in agricultural water usage. The other four water consumer categories, mining, manufacturing, steam-electric, and livestock, utilize much smaller amounts of water and are next projected to change significantly over the next fifty years.

Water supply projections are based on expected changes in infrastructure projects, including completion of planned projects and deterioration of existing ones. These are also calculated regionally and aggregated statewide to produce a statewide estimate of water supply. Figure 4.5 shows the statewide water demand projection together with the water supply projection. This figure shows gradual increases in water demand with a much smaller decrease in projected supply over time. Importantly, this figure also shows water demand exceeding water supply for the entire 50-year projected period.

Although the water plan considers population and water demand projections in detail, climate change projections are dealt with awkwardly. After a discussion of "climate variability" including a reference to the Intergovernmental Panel on Climate

Change's fourth assessment report (Solomon, 2007), the water plan acknowledges that a changing climate would have impacts on Texas's water resources. The water plan even highlights and describes the "Far West Texas Climate Change Conference" convened by the TWDB, at which participants recommended a "regional approach to considering climate change in regional water planning" (TWDB, 2012, p. 153). However, ultimately, the water plan concludes:

> Until better information is available to determine the impacts of climate variability on water supplies and water management strategies evaluated during the planning process, regional water planning groups can continue to use safe yield (the annual amount of water that can be withdrawn from a reservoir for a period of time longer than the drought of record) and to plan for more water than required to meet needs, as methods to address uncertainty and reduce risks. TWDB will continue to monitor climate policy and science and incorporate new developments into the cyclical planning process when appropriate. TWDB will also continue stakeholder and multi-disciplinary involvement on a regular basis to review and assess the progress of the agency's efforts. (TWDB, 2012, p. 154)

Remarkably, the water plan considers in detail quantitative projections for population and water demand, acknowledges the considerable uncertainty in those, but concludes there is too much uncertainty in climate change projections for them to be useful. One can practically see the political fingerprints on this statement and this approach.

The water plan also contains a chapter devoted to risk and uncertainty. It acknowledges the importance of the risk and uncertainty both in water supply and demand projections into the future. Interestingly, the water plan devotes considerable effort to validating the population and water demand projections including a lengthy discussion evaluating past projections from the previous seven Texas water plans for 2010. Through that analysis, the plan notes that there is considerable uncertainty associated with those projections largely due to the changing socioeconomic needs of the state over time. However, with respect to climate change, the water plan notes the "TWDB has taken a number of steps to address uncertainty related to climate variability in the regional planning process. The agency monitors climate science for applicability to the planning process, consults with subject experts, and solicits research… TWDB will continue to monitor drought conditions to determine if a new drought of record occurs, which would change water planning assumptions" (TWDB, 2012, p. 232). Certainly, by that point, it would be much too late to plan for such a drought occurring.

The water plan concludes with six recommendations. The first two recommendations are for building new reservoirs. The third recommendation is to improve the ability to transfer surface water from one basin to another. The fourth recommendation is to adjust the process by which ground water permits are approved. Fifth, the water plan recommends improving water system efficiencies to reduce system loss (e.g., leaks in the systems). Finally, the plan calls on the state legislature to provide financial backing for the water plan's infrastructure projects. Collectively, these goals include elements of infrastructure investment, environmental protection (largely to support infrastructure investment), and sustained public investment in water resources as well as regional self-reliance and reliability.

Public reaction to the water plan was largely one of indifference. A Proquest Newstand search produced only a couple of dozen media references to the 2012 water plan and most of those simply repeated the TWDB's press release content. There was some discussion around the balance between conservation and infrastructure investments proposed in the water plan. Notably, the Nature Conservancy backed the plan noting that "the Conservancy is pleased to see a package that not only helps address our growing water challenges, but clearly recognizes the important role conservation must play in those efforts" ("Nature Conservancy Endorses Early Legislative Efforts to Fund the Texas Water Plan," 2013, p. 1). It is interesting that neither the Nature Conservancy nor anyone else commented on the water plan's treatment of climate change.

4.5 California's 2013 Water Plan

California's first water plan was adopted shortly after the establishment of California's Department of Water Resources (DWR) in 1957. The original plan has been updated ten times since then, including the 2013 update examined here (DWR, 2014). Each update has assessed the state's current and future water resources demands and supplies relying on available data and science. Typically the water plan updates have reported that insufficient water resources will be available to meet future needs and have presented recommendations to address that deficit, including infrastructure projects and conservation. Scholars have made this observation as far back as the 1990s (e.g., Gleick, 1998). Recognizing this, California's 2013 water plan update was developed in parallel with the California Water Action Plan, a water initiative from the California governor's office developed by the California Natural Resources Agency (CNRA, 2014). Whereas the water plan focuses on current and long-term risks to water resources, the Water Action Plan focused "on roadmap for the first five years of the state's journey toward sustainable water management" (CNRA, 2014, p. 1). The two plans are interlinked and extensively cross referenced. For example, the Water Action Plan identified 10 essential actions. The water plan identified 17 objectives, which were mapped onto each of the ten essential actions. Moreover, the fact that the Water Action Plan was developed in the first place indicates a high level of political interest in water in the state.

The water plan includes a comprehensive assessment of annual water resource supply and usage both statewide and regionally over the previous decade. This assessment quantifies annual supplies into four project categories (Colorado River, the USBR Central Valley Project, the DWR State Water Project, and local projects) as well as local imports, groundwater extraction, reuse, recycled, and instream environmental flows. Water usage is quantified for the following categories: urban, irrigated agriculture, managed wetlands, required Delta outflow, instream flows, and wild and scenic rivers.

Climate change is discussed repeatedly throughout the water plan including in the background discussion motivating the imperative to act:

> Specific consequences of climate change are that higher temperatures will melt the Sierra snowpack earlier and drive the snowline higher, resulting in higher peak flood flows and less snowpack to supply water to California users. Rainfall events may become more frequent and intense, contributing to increased flood risk. Droughts may become more frequent and persistent this century. Accelerating sea level rise will produce higher storm surges during coastal storms. Together, higher winter runoff and sea level rise will increase the probability of levee failures in the Delta. Sea level rise will also place additional constraints on water management and exports from the Delta, especially as a result of increased salinity from tidal exchange in the Delta. By the end of the 21st century, the magnitudes of the largest floods may increase from 110 to 150 percent of historical magnitudes. (DWR, 2014, pp. 2-12)

The water plan goes on to describe in detail expected impacts from climate change in water supply, ecosystems, water and power operations, flooding and drought, and coast and delta.

In addition to the qualitative discussion on climate change, the water plan uses quantitative information through scenario development. Projections of future water demand and supply are generated to inform policy recommendations in the water plan. The projections target 2050 in a scenario based approach to attempt to account for uncertainty (Groves & Bloom, 2013). One hundred ninety-eight scenarios are used based on all combinations of 3 population growth scenarios, 3 development density scenarios, and 22 climate scenarios. Population growth and development density scenarios were developed by the University of California at Davis. Each set of three scenarios includes one current trend, one at a lower rate, and one at a higher rate. Acres of irrigated land surface and agriculture were calculated based on the expected urban encroachment into agricultural lands from these scenarios. Climate scenarios were adopted from the Governor's Climate Action Team (12 scenarios) plus 10 scenarios utilizing historical data with a warming trend imposed. Collectively, these scenarios were then used to compute regional scenarios for water supply, agricultural water demand, and urban water demand. Demand scenarios are shown in Figure 4.6. Water management strategies were then tested against each scenario to determine the reliability of water supplies for urban and agricultural areas in regions of California's central valley. The southern central valley (Tulare Lake region) was found to be the least reliable with a majority of scenarios resulting in system failures for both agricultural and urban water systems in that region. By contrast, the Sacramento River region further to the north was shown to have greater system reliability with most urban systems having near 100% reliability across all scenarios. Figure 4.7 shows the reliability for urban and agricultural scenarios across the three major regions.

The 2050 scenarios are then used to inform strategies and recommendations both in the California water plan and in the Water Action Plan. In the water plan, strategies are organized around three themes: integrated water management, strengthening government agency alignment, and investments in innovation and infrastructure. The water plan also articulates a roadmap with a vision, seven goals, 10 guiding principles, 17 objectives, and about 300 actions with performance measures. The roadmap is based on the vision that the “water system provides the certainty needed for quality of life, sustainable, economic growth, business vitality, and agricultural productivity. California’s unique biological diversity, ecological values, and cultural heritage are protected and have substantially recovered” (DWR, 2014, p. 8.7). The water plan roadmap goals include elements of environmental protection (“protect, preserve and enhance watersheds” (DWR, 2014, p. 8.7)), social justice (“benefits and consequences of water decisions … are equitable across all communities” (DWR, 2014, p. 8.8)), sustained public investment in water resources, regional self-reliance and reliability, and preparedness for uncertainty including climate change.

Like Texas, public reception of the 2013 water plan was largely indifference. A Proquest Newstand search revealed only a handful of media outlets commented on the plan. Those that did mostly just repeated the talking points from the DWR press release announcing the water plan release. One exception was the *Contra Costa Times* whose editorial entitled “All Must Get Involved in Water Debates” called on the populace to understand the water plan and to “channel your inner wonk and get involved in the discussion to create access to this essence of life” ("All Must Get Involved in Water Debates," 2014). There is little evidence their readers or even their own reporters followed this advice.

DWR did survey the public for its perception of water supply threats to and security of the water supply. Respondents to the DWR survey indicated large majorities of respondents from each region within the state indicated that they saw threats to future water supplies and they were concerned about the effect of climate change on future water supplies (DWR, 2014, pp. 5.54-55).

4.6 Comparison and Discussion

The first order goal of both California and Texas in their water plans is to identify and address issues regarding their water resources supply and usage. To do so, however, the two states take two very different paths. Table 4.1 presents a summary of Texas and California's water plans by key attributes including publication year, length, water supply and demand projection methodology and output, and policy goals.

4.6.1 Treatment of uncertainty

Both states identify planning for uncertainty as an important element of their plans, including narratives identifying sources of uncertainty and articulating the importance of tracking those sources over time. However, the plans differ significantly in their actual analysis and the use of uncertainty within them. Whereas California utilized a scenario approach to explicitly represent uncertainty through scenarios of population growth, growth patterns, and climate change, Texas employed a single value projection accounting only for changes in population and infrastructure. Furthermore, Texas's approach did not quantify the uncertainty even in the elements it projected to change although it did include a quantitative analysis of past population projections from which uncertainty could be derived and applied to the projections it used. In contrast, California's scenario method for computing different futures, based on different assumptions about climate and urban growth, provided planners both in the California water plan and in regions of California, rich information from which to plan. Each scenario essentially represents a future contingency to plan to test the reliability of the current and proposed future water systems. From that, California water planners can demonstrate the resilience of their system to multiple scenarios. Of course, there are sources of uncertainty that are not represented by the California scenarios including future population and climate scenarios beyond those included in the plan as well as unknown uncertainties. Planners in both states will need to consider reliability broadly to ensure they are prepared, to the extent they can be, for these scenarios.

4.6.2 Climate change

Although climate change is expected to impact the water supply of both states similarly through a reduction in precipitation (e.g., Figure 4.3), the treatment of climate change in their respective water plans is a major contrast. Texas's water plan essentially pays lip service to climate change through hosting a workshop and promising to follow future research on the impact of climate change on water resources. Beyond relatively noncommittal actions, Texas's plan essentially ignores the changing climate. Neither the water supply projections nor the demand projections include or address climate change at all. In stark contrast, California's water plan explicitly identifies adapting to climate change as one of its goals and includes extensive discussion of climate change throughout the plan. The water supply and demand scenarios rely heavily on climate change projections for temperature and precipitation through the inclusion of 22 different climate scenarios.

4.6.3 Public reception

The general public indifference to the water plans was common to both states. Consistent with literature (e.g., Page et al., 1987), this suggests that in technical and/or complex issues such as water management, the public is generally willing to delegate policy making to technocrats such as water planners.

California's plan included an analysis of public opinion that Texas's did not; this suggests that California's planners are perhaps interested in at least documenting public opinion as a supporting element for their plan, if not actually using that opinion to shape their plan. This suggests California's planning effort may be somewhat more egalitarian than Texas's.

4.6.4 Policy choices

Both Texas and California conclude their plans with a series of nonbinding recommendations. These are summarized at the end of Table 4.1. Texas's plan follows the model of a traditional water plan with its emphasis on infrastructure – particularly reservoir – development proposals as the major means of achieving long-term sustainability and reliability of water supplies. It promotes specific projects, and calls on the state legislature to fund and/or provide financial assistance for these projects. It calls on regional planning and authorities to be self-reliant and to execute these projects. It also includes a call for environmental protection within the watershed of proposed projects in order to preserve their effectiveness as a water resources project.

California's plan takes a different path. Although it embraces the importance of water resources infrastructure for reliability, its focus is on integrated water management where flooding, environmental, and water supply needs are balanced against each other. It not only calls out the use of best available science and data as goals, it actually uses them in its plan. Unlike Texas, California calls out social justice as a goal and acknowledges the unequal access to water that currently exists in the state as a problem. Also, in contrast to Texas, environmental protection is identified as a goal in its own right rather than simply as a means of justifying an infrastructure project.

Clearly these paths are different. Whereas the traditional water development path that Texas has chosen has been followed before by many governments around the world (including California), the path that California has chosen is relatively novel. The results of the traditional path are relatively well understood including its benefits for system reliability. However, these results are understood in the context of a stationary rather than changing climate. One of the premises of California's water plan is that new strategies are needed to address not only the changing climate but also the realities of crossing supply and demand curves. California also notes that its current crisis is the result of having followed the traditional water management approach. Time will tell where these paths lead. As many have noted, the states are laboratories for democracy and different policies emerge from different populations with different preferences. That contrast is particularly evident in California and Texas – two similar states with very different politics.

4.7 Beyond Texas and California

To what extent are Texas and California representative of Republican and Democratic voting states, respectively? While Chapter 3 showed the importance of presidential voting in predicting the inclusion of climate science in state water planning, there was considerable variance in the relationship between these variables. In particular, outliers are evident in Figure 3.5 showing state water plan rankings plotted against the state presidential vote. Two of the major outliers are New Mexico, a reliably Democratic state with a water plan ranking of one, and Oklahoma, a reliable Republican state with a water plan ranking of four.

New Mexico’s 2013 water plan update is a brief document – only 66 pages. Although it eloquently describes the need to adapt to changing water conditions, it is silent on the implications of a changing climate within the state. It also lacks much of the quantitative detail that is evident in California’s and Texas’s plans. It has many pictures but only one plot in the entire document. I speculate that this document is reflective of the capacity and sophistication of the state water agency responsible for drafting the state water plan. If New Mexico’s water agency had the resources and depth of expertise that California or other larger states had, it would very likely have a more quantitative water plan and would also account for climate change. It is also possible that New Mexico’s uniquely large Native American and Hispanic populations may shape the state’s water and climate strategies in ways that are different from other states.

Oklahoma is another interesting outlier case from Figure 3.5. Oklahoma’s 2012 water plan contains very detailed watershed analyses and projections that consider climate change in a manner similar to California. In the course of drafting this dissertation, I had the opportunity to participate in meetings with the state water agencies from several states including Oklahoma. Although the focus of those meetings was not on their water planning or even on climate change, it became apparent through observation and interaction that the Oklahoma Water Resources Board has a high level of engineering and analytical capacity. In addition, their leadership has a high level of political acumen to work with their state's conservative political leadership to address areas like climate change that are politically sensitive but important for managing the water resources of the state. I speculate that these two attributes, capacity and political acumen, are key in explaining Oklahoma's deviation in Figure 3.5.

Capacity of water agencies, therefore, may be an important variable to consider across states. California's DWR is a vast department with experience in not only generating water plans but also in operating massive water projects and all that that entails. In contrast, New Mexico's Office of the State Engineer has a diverse portfolio of responsibilities including water planning with a much smaller budget and staff than California. Operationalizing the capacity variable into a study like this one could be done through an analysis of budget and/or staff resources at the state-level for water resource planning. Obtaining these data in a consistent manner and accounting for the different populations and sizes of the states would be somewhat challenging. Nonetheless, this variable would add significant insight to the results of this study.

Table 4.1: Comparison of Texas and California water plans.

Attribute	Texas	California
Update Examined	2012	2013/2014
Page Count	299	3000+
Time Horizon	2060	2050
Projection methodology	Single projection with qualitative discussion on uncertainty	198 scenario projections quantifying uncertainty together with qualitative uncertainty
Projection inputs	Population	Population, Growth density, Precipitation, Temperature
Projection outputs	Water demand by six categories and regionally	Water supply and demand scenarios regionally by urban and agriculture
Water plan policy goals	Infrastructure development Environmental protection Sustained public investment Regional self-reliance and reliability	Environmental protection Social justice Sustained public investment Regional self-reliance and reliability Preparedness for uncertainty including climate change

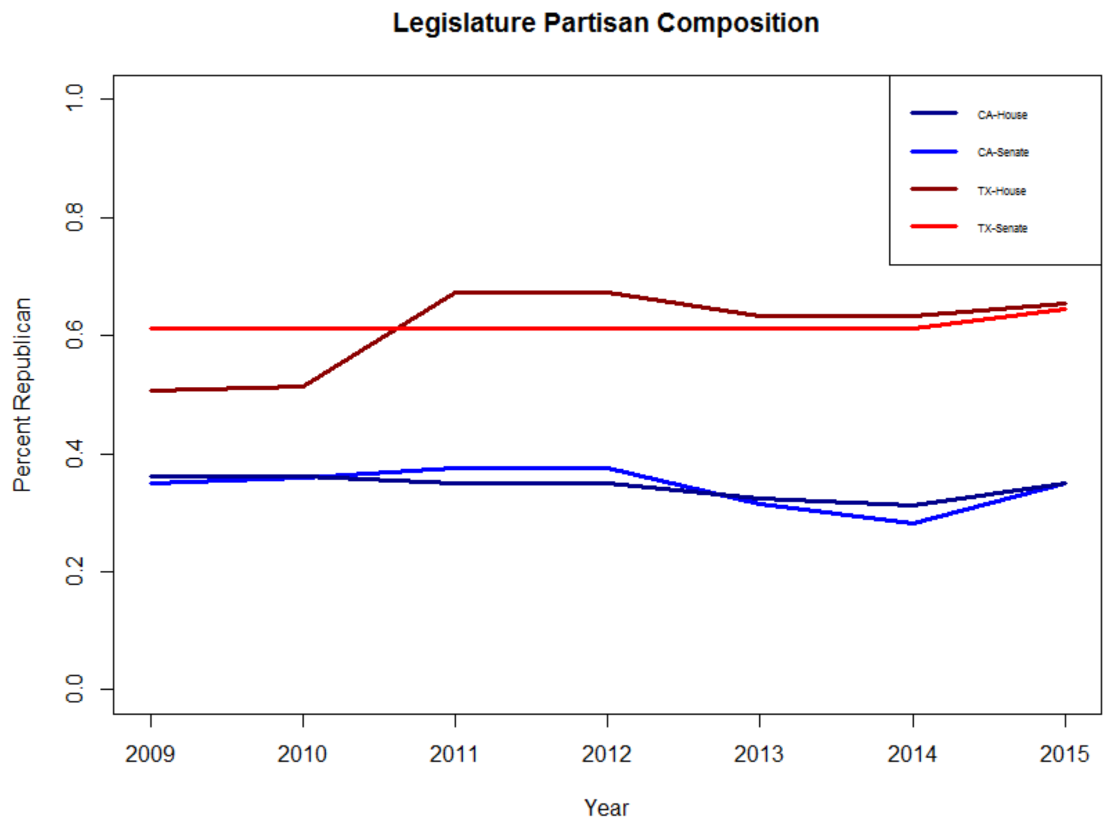

Figure 4.1: Partisan composition of California and Texas state legislatures (data from NCSL, 2015).

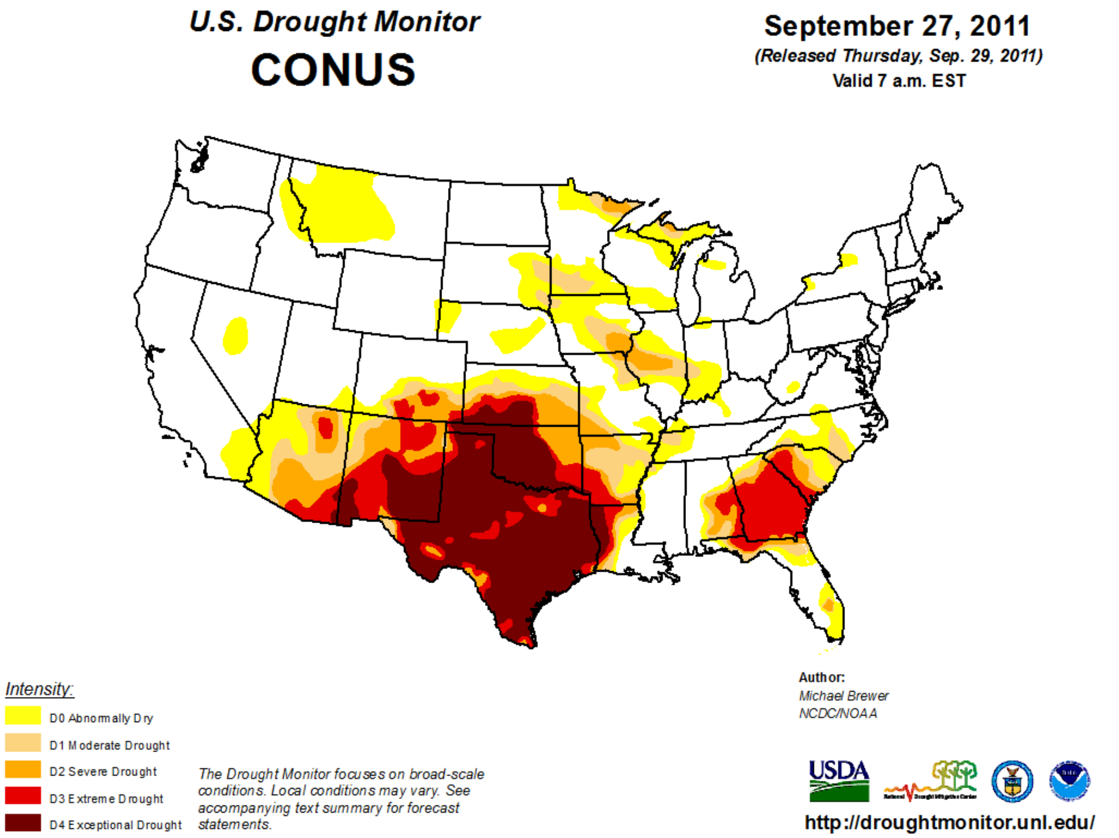

Figure 4.2: US drought monitor for September 27, 2011. Reprinted with permission from the National Drought Mitigation Center – University of Nebraska Lincoln (NDMC-UNL). The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Map courtesy of NDMC-UNL (USDM, 2015).

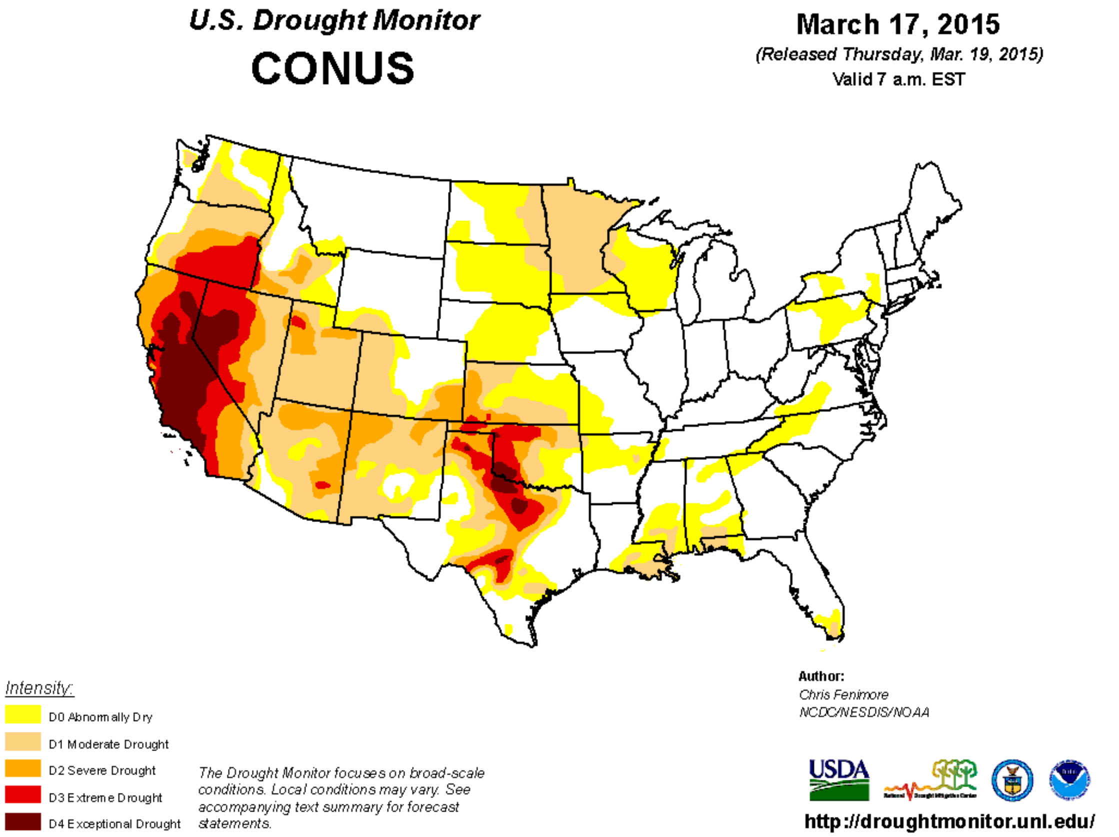

Figure 4.3: US Drought Monitor for March 17, 2015. Reprinted with permission from the National Drought Mitigation Center – University of Nebraska Lincoln (NDMC-UNL). The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Map courtesy of NDMC-UNL (USDM, 2015).

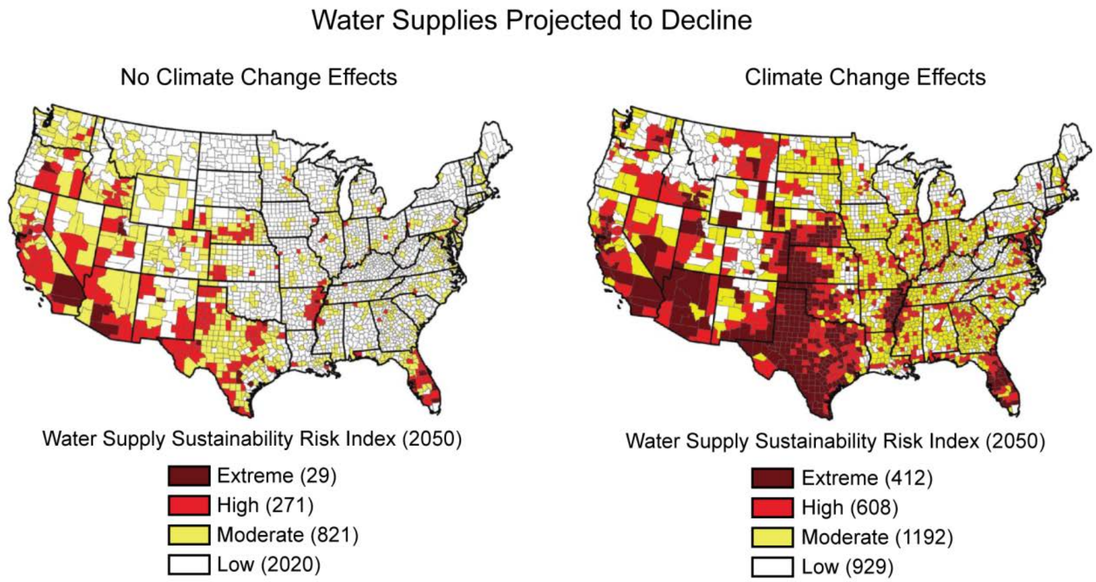

Figure 4.4: Water resource risk index. Reprinted with permission from Roy et al. (2012) as it appeared in the Third National Climate Assessment (Georgakakos et al., 2014). Copyright 2012 American Chemical Society.

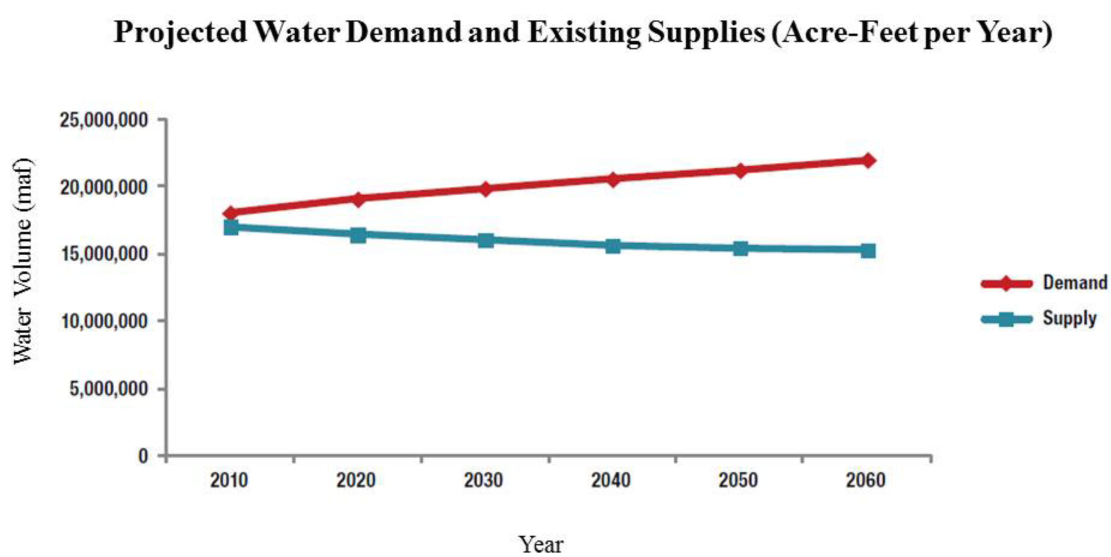

Figure 4.5: Projected water supply and demand for Texas. Reprinted with permission from the Texas Water Development Board (TWDB, 2012, Figure ES-2).

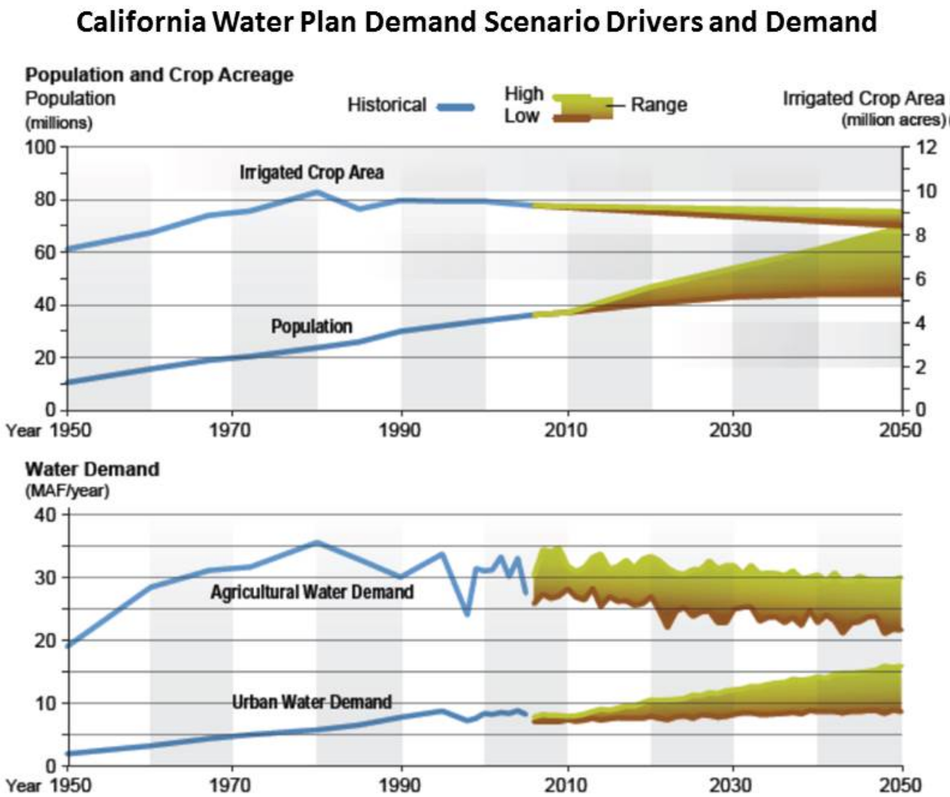

Figure 4.6: California projected water demand using scenario approach. Reprinted with permission from the California Department of Water Resources (DWR, 2014, Figure 5-1).

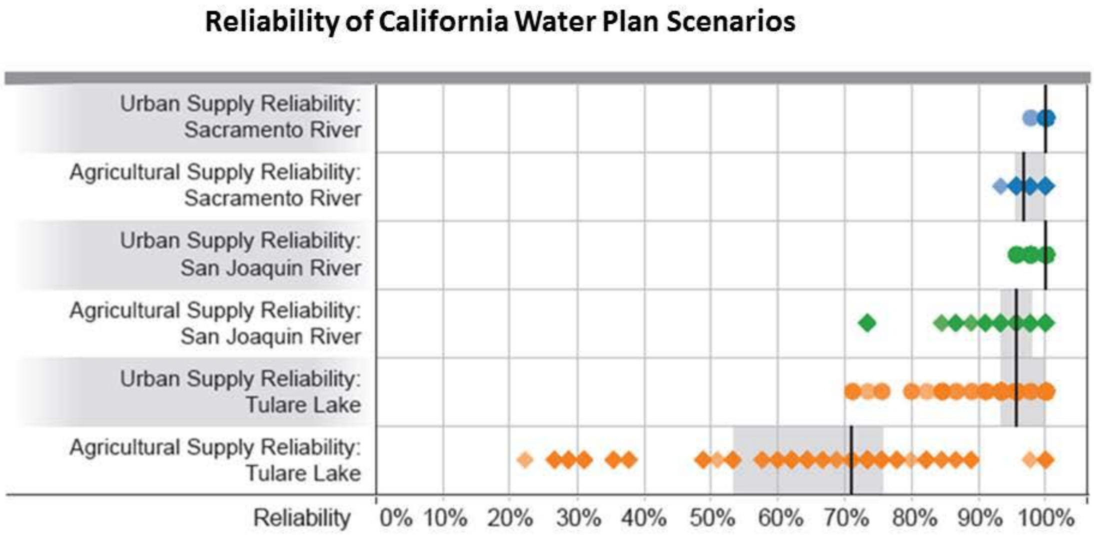

Figure 4.7: Projected reliability of California's major agriculture and uran water systems. "Circles indicate urban reliability results, and diamonds indicate agricultural reliability results. Blue, green, and orange symbols correspond to results for the Sacramento River, San Joaquin River, and Tulare Lake hydrologic regions, respectively." (DWR, 2014, Figure 5-11). Reprinted with permission from the California Department of Water Resources.

CHAPTER 5

CONCLUSIONS AND IMPLICATIONS

The overall drive of this study has been to identify motivating variables for governments and individuals to form policy preferences for addressing climate change in planning at the state-level. In particular, water planning was chosen as the substantive focus because of both its major importance to all aspects of life and the documented impacts of climate change on water resources. Various motivating variables including vulnerability to climate change, recent experience with drought and natural disasters, political preferences, and education were considered. All variables were tested for significance in predicting for incorporation of climate change impacts in state-level water planning using regression models and data from between 2007 and 2014. The only consistently significant predictor across differing permutations of the models was political preference as expressed through presidential vote. To further examine this quantitative study result using a different research method, the last empirical chapter presented a comparative case study. This study compared water planning in two states, Texas and California, with very different politics but otherwise similar populations, experience with drought and water resource challenges, and vulnerability to climate change. Taken together, the multimethod study shows that Democratic states are significantly more likely than Republican states to incorporate projections for the changing climate in their water plans.

These studies also showed considerable unexplained variance (e.g., in Figures 3.5 and 3.6). Although much of the differences between state approaches to addressing climate change in their water planning and state hazard mitigation planning efforts can be explained by political differences. Many of the differences are not explained by political differences or the other variables considered in this study. Understanding these differences requires further and deeper investigation along the lines of the comparison study in Chapter 4 for Texas and California. For example, understanding and operationalizing variable(s) to describe water agency capacity, resources, and political acumen are likely critical to explaining the water planning in New Mexico and Oklahoma.

While this study produced robust results across different research methods and different configurations of modeling and data, it does have limitations. Limitations include data, sample size, sampling, and timeliness. The data used in this study were drawn from different sources with varying levels of measurement. For example, the lack of a consistent state-level data set on water resources vulnerability that led to the aggregation of the Padowski and Jawitz (2012) city-level data to state-level in this study, (Chapter 3) was a challenge this study overcame. Sample size is another limitation. Using state-level data, the largest possible sample is 50, but this study often included fewer states. This was particularly the case for the water plans as only 29 out of 50 states have water plans. Although the sample size limitation was partially mitigated by running permutations of the regression models with differing subsamples to test for significance, the results are fundamentally limited to the data available. The samples themselves (e.g., state-level data) are also quite diverse in their depth. Water planning is much more limited in scope for smaller states than it is for larger states. Finally, the results are necessarily time bound. Chapter 2 demonstrated that the drivers for climate change policy preferences at the state-level have evolved over time with more recent results showing a stronger connection between partisan identification and policy preferences on climate change. As policy and political drivers continue to change into the future, the relationships documented will likely continue to evolve as well and should, therefore, be reassessed over time.

Even with these limitations, the results of this study have implications both for future research and for practitioners in water resources planning.

5.1 Opportunities for Research

Future research should build on this study in at least five areas: improving data, testing results on a different unit of analysis, comparing with research studying risk management on different time and space scales, further exploring the linkage between water planning and politics, and testing state planning efforts in other areas for similar relationships.

As previously discussed, one of the challenges in conducting this study was the available data. The most limiting aspect was the lack of an existing, robust dataset on state-level water vulnerability. As the US water census (USGS, 2015) that Congress funded the USGS to conduct in order to quantify water systematically across the country is developed in the coming years, that dataset should address this limitation. Further, new data will be available including new polling data similar to the Pew (2010) dataset, data from future election results, and new water plans. Each of these datasets will provide an opportunity to repeat this study. There will also be increasing opportunities for conducting longitudinal studies over time to assess how the relationships between predictor variables and water planning evolve. Moreover, as the pace of climate change accelerates and its impacts on water resources become more evident over the coming years, that too will provide an interesting basis for research into how states that currently ignore climate change might change their planning approach to incorporate climate change projections.

Second, repeating this study with a different unit of analysis, water district planning, would be revealing. In particular, a unit of analysis focused on water districts with responsibility for providing water to their customers would be very interesting. Water districts are typically much smaller than states, more removed from the politics than state government, and, unlike most states, have direct responsibility for providing water. Water districts are typically run by professional directors with engineering backgrounds. Their governance structures vary widely although directors generally report to a governing body with representatives elected by the voters in the district or appointed by elected leaders in the district. Perhaps because water districts are singularly focused on water, their governing bodies tend to be much less partisan and political than state legislatures and governors that ultimately oversee state water planning efforts. It is therefore likely that at the water district level, district directors would have more latitude in their planning efforts generally but also specifically to consider climate change than at the state-level. This hypothesis could be tested by repeating some elements of this study at the water district level. However, such a study would be challenged to collect the political data needed as those datasets are not readily available at the water district level. In addition, as with states, water districts vary considerably in size and planning capabilities. Controlling for those differences could conceivably be done using a case study approach similar to Chapter 4.

Planning for major river basins that include multiple states, countries, and/or water districts is another unit of analysis that offers an interesting scale for future research questions (e.g., Feldman, 2013). Unlike the state or water district level, there is not typically a single water management agency responsible for planning or governing water across the major river basin. Instead, water at the major river basin scale is typically governed by long standing treaties or compacts between the states, countries, and/or water districts with interests in the basin. These governing instruments may be amended over time to address challenges, conflicts, or evolving needs by the signatories. An example of a major river basin is the Colorado River basin that encompasses seven states and two countries and provides a setting for examining the water planning of multiple entities with a shared resource. Water in the Colorado River Basin is allocated between the seven US states according to the 1922 Colorado Compact, subsequent agreements between the states, and legal decrees from the US court system. Water is allocated between the US and Mexico according to the 1944 Mexican Water Treaty and its amendments. In the context of this study, how do plans for a resource shared among politically diverse states consider climate change? The Colorado River Basin includes states like California that have demonstrated a desire to plan for a changing climate but also states like Arizona that have refused. The Colorado River Basin Study produced by the federal government in partnership with the seven basin states is fertile ground for such a study (USBR, 2010).

A third avenue of future research is a comparison of the relative importance and application of science and of politics in water planning with crisis management for other natural phenomena such as flooding or earthquakes. In each of those phenomena, there is both a body of scientific knowledge around predicting and understanding the phenomena itself and political policy choices around mitigating or reducing the impacts. For flooding this would include construction of flood control facilities such as dams, levees, etc., and for earthquakes there is emerging evidence of the impact of hydraulic fracturing leading to increased earthquake activity. Moreover, there is considerable literature on ways that different cultures consider and act on risk. For example, Bernhardsdottir (2013) examines how four different types of cultures (fatalism, individualism, hierarchy, and egalitarianism) perceive risk in crisis management. In this context, Texas might be characterized as more individualistic and California as more egalitarian. This characterization could be refined and tested in policy areas outside of water planning and used to predict planning tendencies.

Next, although this study documented partisan based policy differences in how state water plans address climate change, it leaves unanswered how exactly those political preferences manifest themselves into state policy. Are water planners in Democratic states more likely to address climate change because they themselves are more predisposed to it? Are they receiving direction from their political leadership? And how does that work in the “outlier” states such as Republican Oklahoma that addressed climate change extensively in its planning efforts or Democratic New Mexico that largely ignored it? These differences were discussed at the end of Chapter 4 and water agency capacity was proposed as a possible variable to further explain differences between states. Understanding these exceptions might shed light on what other drivers exist.

Finally, future research should examine state planning efforts in other areas to test if similar relationships are observed with incorporating climate change within those plans and the partisan composition of the state electorate. States that routinely generate plans in a myriad of areas will likely be impacted by climate change including transportation, public health, land use, energy, and even climate adaptation. Plans within each of these areas could be assessed in a manner similar to this study to both assess planning within different substantive areas of planning and to compare results with water planning and hazard mitigation planning. Do some areas of planning incorporate climate change more than others? Are some areas of planning more buffered from politics than others? Are plans within a particular state consistent in how they address climate change? These questions might be addressed through a similar procedure as in this study to compare state hazard mitigation planning and state water planning (recall Table 3.3, for instance). Understanding differences in planning sensitivities to political pressures across substantive planning fields would illuminate motivators for planning in those fields.

5.2 Implications for Practice

Water resource managers and those that support them may also benefit from the results of this study. There are at least three major implications for water resource planners, water management agencies, and their constituents: first is to understand their political landscape, second is to track outcomes of their plans, and third is for scientists and practitioners to have open channels of communication.

Like many professions, practitioners in water resources tend to focus on their craft and ignore the seemingly unconnected politics around them. However, this study demonstrated tangible differences in how states with different political leanings approach climate change. The California and Texas comparison also hinted at a different approach to planning for uncertainty beyond climate change (i.e. future population and urban vs. agricultural water demands). By better understanding the political agendas of their elected leaders and of the populations they serve, water resource practitioners will likely be better able to shape their own activities to meet those agendas but also to bring their own considerable expertise in water resource management to meet the water challenges of their customers in the most effective manner possible.

Finally, water planners should track outcomes associated with their planning efforts. It is clear that the California and Texas water plans prescribe not only two very different types of investments but also articulate two different sets of goals. While both states are ultimately interested in meeting the water needs of their state, they diverge considerably on both what that means and how they will get there. Whereas Texas proposes traditional investments in infrastructure expansion and conservation, California proposes investments in the environment and in socially equitable distribution of water resources. Water agencies should carefully measure how the prescriptions in their plans make progress to their stated goals. Over time, the relative success of each strategy should be assessed and contrasted with other strategies. Ultimately, this is how we learn. In releasing California's water plan, California's Secretary for Natural Resources, John Laird remarked, "Climate change has essentially nullified the century-old" model for water management where historic climate is assumed to represent future climate ("All Must Get Involved in Water Debates," 2014). California has developed a new model in its water plan. It should be tested and improved over time.

As climate scientists themselves have pointed out in climate assessments, climate change will have pronounced impacts on water resources in many regions of the country. The state water plans and state hazard mitigation plans analyzed in this study shows considerable variability in how states recognize or incorporate climate change projections into their planning efforts. In some cases where states are either not acknowledging likely impacts of climate change in their planning narratives or are not incorporating climate change into their future scenarios that they plan to do so, there may not be sufficient communication between planners and the climate science community. These communities should be communicating with each other to ensure that planners have access to the best available science for their planning efforts and that scientists are aware of the thresholds and planning requirements so they can tailor their activities to produce relevant information.

Overall, understanding the connections between politics and the activities undertaken by political entities is critical for anyone seeking to influence either the politics or the activities of the state. This study demonstrated both the impact of politics on state planning activities and the presence of exceptions. For those seeking to better connect government activities to the policy preferences of elected leaders, this study offers broad support for the idea that elections do matter and that elected leaders do have considerable impact on state government planning in water and especially in hazard mitigation planning. For those seeking a more technocratic approach to major problems, this study offers evidence that unelected government technocrats have power, particularly in water planning to interject technical expertise into planning processes.

APPENDIX

CODING SCHEME: CATEGORIZATION OF CLIMATE CHANGE TREATMENT IN STATE HAZARD MITIGATION AND STATE WATERPLANS

Coding Instructions

Background: FEMA requires each state to develop a State Hazard Mitigation Plan. These plans are intended to assess risks, organize resources, and establish a plan for mitigating risks with available resources. Each state is responsible for developing their own risk assessment and plan and presenting those in their State Hazard Mitigation Plan. As such, those plans address the hazards posed by climate change in different ways. Babcock (2013) defined an "intentionally broad" ranking system for categorizing how each state treats climate change. He used a four category system defined as follows:

1. No discussion of climate change or inaccurate discussion of climate change
2. Minimal mention of climate change related issues
3. Accurate but limited discussion of climate change and/or brief discussion with acknowledgement of need for future inclusion
4. Thorough discussion of climate change impacts on hazards and climate adaptation actions

States were qualitatively assigned to categories based on the following criteria:

1. Effect of climate change considered (quantitatively, qualitatively, anecdotally)

2. Adaptation to climate change considered (explicitly, implicitly, targeted, or general)

3. Summary of climate change presentation

In order to apply Babcock's (2013) to state water plans, the following coding schema is used to reproduce Babcock's (2013) rankings for state hazard mitigation plans before applying this schema to state water plans.

Schema

1. Search appropriate risk assessment documents for occurrences of "climate change." Assess surrounding text for criteria 1 (effect of climate change considered). If no discussion or grossly inaccurate discussion is present, assign state to category 1. If discussion is present, proceed to step 2.

2. If climate change does not have its own section, is minimal in nature, and does not acknowledge the need for future inclusion, assign to category 2. Otherwise proceed to step 3.

3. If there is a thorough discussion of the impacts of climate change on hazards identified and identification of climate adaptation actions, assign to category 4. Otherwise assign to category 3.

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